

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

THIS PAGE BLANK (USPTO)



(11) **EP 1 114 744 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.07.2001 Bulletin 2001/28

(51) Int Cl.7: **B60K 6/02, B60K 17/16,
F16H 57/00**

(21) Application number: **00127348.1**

(22) Date of filing: **13.12.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **27.12.1999 JP 37184599**
27.12.1999 JP 37184699
28.09.2000 JP 2000295672

(71) Applicant: **AISIN AW CO., LTD.**
Anjo-shi Aichi 444-1192 (JP)

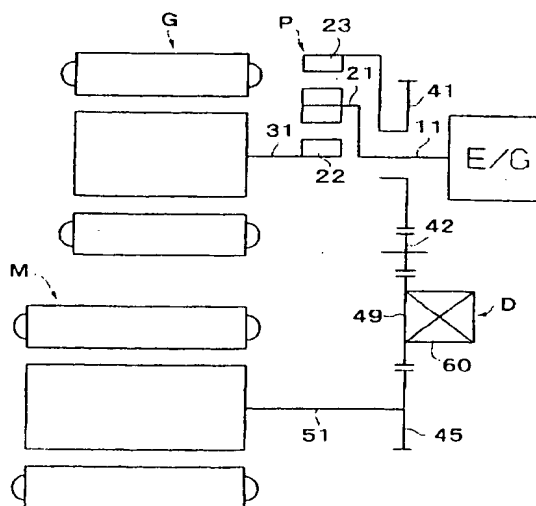
(72) Inventors:
• **Takenaka, Masayuki, c/o AISIN AW CO., LTD.**
Anjo-shi, Aichi-ken, 444-1192 (JP)
• **Kutsuna, Naruhiko, c/o AISIN AW CO., LTD.**
Anjo-shi, Aichi-ken, 444-1192 (JP)

(74) Representative:
Leson, Thomas Johannes Alois, Dipl.-Ing. et al
Patentanwälte
Tiedtke-Bühling-Kinne & Partner,
Bavariaring 4
80336 München (DE)

(54) **Gearing arrangement in hybrid drive apparatus**

(57) The gear noise reduction measures is simplified as well as the optional setting alteration of the total gear ratio on the engine side is enabled without altering the mutual positions between axes A hybrid drive apparatus is formed from an engine (E/G), a generator (G), a differential gear mechanism (P) linking the above two, an electric motor (M), and a differential apparatus (D). The power transmission system on the side of the engine that links the differential apparatus (D) with the output element of the differential gear mechanism (P) and the power transmission system on the side of the electric motor that links the differential apparatus (D) with the electric motor are each formed from separate power transmission elements and are each linked to the differential apparatus at the most downstream point of the power transmission system of each. As a result, it is possible to arbitrarily alter the setting of the total gear ratio on the engine side simply by altering the meshing diameter of the power transmission elements without altering the mutual positions between the axes of the engine (E/G), electric motor (M), and differential apparatus (D). Moreover, the implementing of measures against noise is simplified because the upstream side of the power transmission system that has a high probability of being the one generating problem noise is formed separately.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a hybrid drive apparatus that uses an engine and an electric motor as power sources, and in particular, to a drive link structure for linking power transmission systems of an engine and an electric motor in the hybrid drive apparatus.

2. Description of the Related Art

[0002] A hybrid drive apparatus that uses an engine (i.e. an internal combustion engine) and an electric motor as power sources transmits the power from the two systems to a differential apparatus and, therefore, a variety of power train structures can be adopted. Among these, technology for a drive apparatus having an excellent structure in that the output from the engine and the output from the electric motor are transmitted to a differential apparatus with an optional gear ratio being set for each is disclosed in Japanese Patent Application Laid-Open (JP-A) No. 8-183347). In this drive apparatus, the engine and generator are placed on a first axis, the electric motor is placed on a second axis, a countershaft is placed on a third axis, and the differential apparatus is placed on a fourth apparatus. A structure is employed in which the engine and generator are linked to the countershaft via a differential gear mechanism and the electric motor and differential apparatus are linked directly to the countershaft. Because the power of the two systems is transmitted to the vehicle wheels via the countershaft, a counter driven gear (the third gear 32 in the terminology of the aforementioned publication) is engaged with a drive gear (the first gear 15 in the terminology of the aforementioned publication) drive linked to the engine and a drive gear (the second gear 27 in the terminology of the aforementioned publication) drive linked to the motor, and the outputs from both the engine and the motor are input to the countershaft at optionally set gear ratios for each.

[0003] It should be noted that, as regards the engine in a hybrid drive apparatus such as that described above, it is not rare for the demands on the vehicle to be different for each vehicle. Namely, some vehicles may place precedence on fuel consumption, while some vehicles may place precedence on acceleration. In this case, it is necessary to set the total gear ratio from the engine to the wheels higher for the former, and to lower this ratio for the latter. In order to respond to these demands in the above hybrid drive apparatus, the diameters of the gear pairs linking the differential gear mechanism and the countershaft are altered so as to alter the total gear ratio on the engine side. However, this results in the diameter of the gear pairs linking the electric motor and the countershaft also having to be altered which af-

fects the gear ratio on the motor side. Moreover, as a result of the diameter of the gears being altered, the center distance between the countershaft on the third axis and the differential apparatus on the fourth axis is also changed which results in the configuration of the casing that surrounds these also needing to be altered.

[0004] Further, from the standpoint of gear noise as well, the engine side drive gear and the motor side drive gear mesh simultaneously with the counter driven gear, and gear face precision between the engine side drive gear and the counter driven gear and between the motor side drive gear and the counter driven gear must be provided simultaneously, which requires a great deal of man-hours. Moreover, because the meshing degree (noise frequency) is the same, not only is louder gear noise generated, but it is not possible to determine from differences in the noise frequency whether the meshing portion causing the noise is between the counter driven gear and the engine drive gear or between the counter driven gear and the motor drive gear, which makes it impossible to implement measures to reduce the noise.

SUMMARY OF THE INVENTION

[0005] Therefore, the first object of the present invention is to provide a hybrid drive apparatus capable of allowing the optional setting and further altering of total gear ratios on the engine side and on the motor side without the axial positions of the engine and generator, the electric motor, and the differential apparatus being altered. The second object of the present invention is to then simplify noise reduction measures when gear noise that needs to be reduced is generated in the hybrid drive apparatus.

[0006] In order to achieve the above objects, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, an electric motor, and a differential apparatus, in which an output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor are each formed from separate power transmission elements, and both are drive linked at the most downstream ends of their respective power transmission systems with the differential apparatus.

[0007] Specifically, the power transmission system on the side of the engine and generator is formed from pow-

er transmission elements that drive link the output element of the differential gear mechanism and a diff input gear of the differential apparatus, and wherein the power transmission system on the side of the electric motor is formed from power transmission elements that drive link a rotor shaft of the electric motor and the diff input gear.

[0008] In the above structure, it is effective if the diff input gear of the differential apparatus includes a first and a second diff input gear; the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the first diff input gear; and the power transmission system on the side of the electric motor is formed from power transmission elements that drive link the rotor shaft of the electric motor and the second diff input gear.

[0009] Next, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, an electric motor, and a differential apparatus, in which the output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and wherein the power transmission system on the side of the electric motor is drive linked to the differential apparatus via the power transmission system on the side of the engine and generator.

[0010] Specifically, the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the diff input gear of the differential apparatus, and wherein the power transmission system on the side of the electric motor is formed from power transmission elements that drive link the rotor shaft of the electric motor and the output element of the differential gear mechanism.

[0011] More specifically, it is effective if the power transmission system on the side of the engine and generator is formed from a counter drive gear linked to the output element of the differential gear mechanism and power transmission elements that drive link this counter drive gear and the diff input gear, and wherein the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor shaft of the electric motor power transmission elements that drive link this electric motor output gear and the counter drive gear.

[0012] In the above structure, it is effective if the power transmission system on the side of the engine and generator is formed from a first counter drive gear linked

to the output element of the differential gear mechanism and power transmission elements that drive link this first counter drive gear and the diff input gear, and wherein the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor shaft of the electric motor power transmission elements that drive link this electric motor output gear and a second counter drive gear linked to the output element of the differential gear mechanism.

[0013] Moreover, in the above structure, it is also effective if the power transmission system on the side of the electric motor includes a sprocket fixed to the rotor shaft of the electric motor; a sprocket linked to the output element of the differential gear mechanism; and a chain entrained between the two sprockets.

[0014] Next, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, an electric motor, and a differential apparatus, in which the output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and wherein the power transmission system on the side of the engine and generator are drive linked to the differential apparatus via the power transmission system on the side of the electric motor.

[0015] Specifically, the power transmission system on the side of the electric motor is formed from power transmission elements drive linking the rotor shaft of the electric motor and the diff input gear of the differential apparatus, and the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the rotor shaft of the electric motor.

[0016] More specifically, the power transmission system on the side of the electric motor is formed from the electric motor output gear fixed to the rotor shaft of the electric motor and power transmission elements drive linking the electric motor output gear and the diff input gear, and the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the electric motor output gear.

[0017] In the above structure, it is effective if the power transmission system on the side of the electric motor is formed from the first electric motor output gear fixed to the rotor shaft of the electric motor and power transmission elements drive linking the first electric motor output gear and the diff input gear, and the power trans-

mission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the second electric motor output gear that is fixed to the rotor shaft of the electric motor.

[0018] Moreover, in the above structure, the power transmission system on the side of the engine and generator includes a sprocket linked to the output element of the differential gear mechanism; a sprocket fixed to the rotor shaft of the electric motor; and a chain entrained between the two sprockets.

[0019] Next, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, and an electric motor, in which an output element of the differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein the hybrid drive apparatus is provided with output shafts drive linking each of the power transmission systems and the vehicle wheels, and the power transmission system on the side of the engine and generator is formed from power transmission elements drive linking the output element of the differential gear mechanism and a first output gear fixed to an output shaft, and the power transmission system on the side of the electric motor is formed from power transmission elements drive linking the rotor shaft of the electric motor and a second output gear fixed to an output shaft.

[0020] Next, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, and an electric motor, in which an output element of the differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein the power transmission system on the side of the engine and generator is formed from a first counter drive gear linked to an output element of the differential gear mechanism and power transmission elements drive linking this first counter drive gear and the vehicle wheels, the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor of the electric motor and power transmission elements drive linking this electric motor output gear and a second counter drive gear linked to an output element of the differential gear mechanism, and the power transmission system on the side of the electric motor is drive linked to the vehicle wheels via the power transmission system on the side of the engine and generator.

[0021] Next, the present invention is a hybrid drive apparatus including an engine, a generator, a differential gear mechanism linking the engine and the generator, and an electric motor, in which an output element of the

differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein the power transmission system on the side of the electric motor is formed from a first electric motor output gear fixed to the rotor of the electric motor and power transmission elements drive linking this first electric motor output gear and the vehicle wheels, the power transmission system on the side of the engine and generator is formed from power transmission elements drive linking the output element of the differential gear mechanism and a second electric motor output gear fixed to the rotor shaft of the electric motor, and the power transmission system on the side of the engine and generator is drive linked to the vehicle wheels via the power transmission system on the side of the electric motor.

[0022] In the structure of each aspect of the invention as mentioned above, an idler gear may constitute the power transmission element.

[0023] In the structure of each aspect of the invention as mentioned above, a counter reduction mechanism may constitute the power transmission element as a counter reduction gear mechanism.

[0024] In the structure of each aspect of the above invention as mentioned above, it is possible to constitute the power transmission element in one of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor as an idle gear, and to constitute the power transmission element in the other of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor as a counter reduction gear mechanism.

[0025] In the structure of each aspect of the above invention as mentioned above, it is effective if a coaxial reduction mechanism is inserted in at least one of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] Fig. 1 is a skeleton view of the hybrid drive apparatus according to the first embodiment of the present invention;

[0027] Fig. 2 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the first embodiment;

[0028] Fig. 3 is a skeleton view of the hybrid drive apparatus according to the second embodiment of the present invention;

[0029] Fig. 4 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the second embodiment;

[0030] Fig. 5 is a skeleton view of the hybrid drive ap-

paratus according to third embodiment of the present invention;

[0031] Fig. 6 is a skeleton view of the hybrid drive apparatus according to the fourth embodiment of the present invention;

[0032] Fig. 7 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the fourth embodiment;

[0033] Fig. 8 is a skeleton view of the hybrid drive apparatus according to the fifth embodiment of the present invention;

[0034] Fig. 9 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the fifth embodiment;

[0035] Fig. 10 is a skeleton view of the hybrid drive apparatus according to the sixth embodiment of the present invention;

[0036] Fig. 11 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the sixth embodiment;

[0037] Fig. 12 is a skeleton view of the hybrid drive apparatus according to the seventh embodiment of the present invention;

[0038] Fig. 13 is a skeleton view of the hybrid drive apparatus according to the eighth embodiment of the present invention;

[0039] Fig. 14 is a skeleton view of the hybrid drive apparatus according to the ninth embodiment of the present invention;

[0040] Fig. 15 is a skeleton view of the hybrid drive apparatus according to the tenth embodiment of the present invention;

[0041] Fig. 16 is a skeleton view of the hybrid drive apparatus according to the eleventh embodiment of the present invention;

[0042] Fig. 17 is a skeleton view of the hybrid drive apparatus according to the twelfth embodiment of the present invention;

[0043] Fig. 18 is a skeleton view of the hybrid drive apparatus according to the thirteenth embodiment of the present invention;

[0044] Fig. 19 is a skeleton view of the hybrid drive apparatus according to the fourteenth embodiment of the present invention;

[0045] Fig. 20 is a skeleton view of the hybrid drive apparatus according to the fifteenth embodiment of the present invention;

[0046] Fig. 21 is a skeleton view of the hybrid drive apparatus according to the sixteenth embodiment of the present invention;

[0047] Fig. 22 is a skeleton view of the hybrid drive apparatus according to the seventeenth embodiment of the present invention;

[0048] Fig. 23 is a skeleton view of the hybrid drive apparatus according to the eighteenth embodiment of the present invention;

[0049] Fig. 24 is a skeleton view of the hybrid drive apparatus according to the nineteenth embodiment of

the present invention;

[0050] Fig. 25 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the nineteenth embodiment;

5 [0051] Fig. 26 is a skeleton view of the hybrid drive apparatus according to the twentieth embodiment of the present invention;

[0052] Fig. 27 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the twentieth embodiment;

10 [0053] Fig. 28 is a skeleton view of the hybrid drive apparatus according to the twenty-first embodiment of the present invention;

[0054] Fig. 29 is a skeleton view of the hybrid drive apparatus according to the twenty-second embodiment of the present invention;

15 [0055] Fig. 30 is a skeleton view of the hybrid drive apparatus according to the twenty-third embodiment of the present invention;

20 [0056] Fig. 31 is a skeleton view of the hybrid drive apparatus according to the twenty-fourth embodiment of the present invention;

[0057] Fig. 32 is a skeleton view of the hybrid drive apparatus according to the twenty-fifth embodiment of the present invention;

25 [0058] Fig. 33 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the twenty-fifth embodiment;

[0059] Fig. 34 is a skeleton view of the hybrid drive apparatus according to the twenty-sixth embodiment of the present invention; and

30 [0060] Fig. 35 is an arrangement diagram showing the meshing relationships between each gear of the power transmission systems of the twenty-sixth embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0061] Embodiments of the present invention will be described hereinafter referring to the drawings. Firstly, Fig. 1 shows a skeleton view expanded between the axes of a power train of the hybrid drive apparatus of the first embodiment to which the present invention has been applied. This apparatus is provided with an engine E/G, a generator G, a differential gear mechanism P linking the engine E/G and the generator G, an electric motor M, and a differential apparatus D. The basic structure is formed by the output element of the differential gear mechanism P, which includes a single pinion structure planetary gear set, being drive linked to the differential apparatus D via the transmission system on the engine and generator power side (this is abbreviated in the description in the embodiments below to "engine power transmission system"). The drive apparatus in this embodiment is a transverse type drive apparatus for a front engine front drive (FF) vehicle or rear engine rear drive (RR) vehicle in which the engine E/G, the generator G, and the differential apparatus P are placed on

a common axis, while the electric motor M and the output shaft of the differential apparatus D are placed on different axes respectively that are parallel with the above common axis.

[0062] In this drive apparatus, the engine power transmission system and the electric motor transmission system are each formed from separate power transmission elements and the differential apparatus D is connected at the most downstream point of the power transmission flow of each power transmission system.

[0063] The output shaft 11 of the engine E/G is linked to a carrier 21 of the planetary gear forming the differential gear mechanism P so that the engine E/G is linked with the generator G and the engine side power transmission system. The output shaft 31 of the generator G is linked to a sun gear 22 of the differential gear mechanism P so that the generator G is linked with the engine E/G and engine side power transmission system. As a result, the ring gear 23 of the differential gear mechanism P functions as an output element for transmitting the power of the engine E/G to the engine side power transmission system

[0064] The engine side power transmission system is formed from power transmission elements linking the ring gear 23, which is the output element of the differential gear mechanism P, to a diff ring gear 49 fixed to the diff case 60 as an input gear of the differential apparatus D. The electric motor side power transmission system is formed from power transmission elements linking a rotor shaft 51 of the electric motor M with the diff ring gear 49 of the differential apparatus D.

[0065] The power transmission elements of the engine side power transmission system in the present embodiment is composed of a counter drive gear 41 linked to the ring gear 23 and an idle gear 42 that meshes with the counter drive gear 41 and the diff ring gear 49. The power transmission elements of the electric motor side power transmission system includes an electric motor output gear 45 fixed to the rotor shaft 51. The electric motor output gear 51 meshes with the diff ring gear 49 of the differential apparatus D.

[0066] As can be seen from the actual positional relationships of the axes shown in Fig. 2, this drive apparatus is formed with the engine E/G (see Fig. 1) and the generator G both on the same axis 1, the electric motor M on the second axis, and the differential apparatus D on the third axis, and these axes are parallel with each other. The counter drive gear 41 on the first axis meshes with the diff ring gear 49 of the differential apparatus D on the third axis via the idle gear 42. The electric motor output gear 45 on the second axis meshes with the same diff ring gear 49 at a different position in the peripheral direction.

[0067] In a hybrid drive apparatus having the above described structure, in contrast to the electric motor M and the differential apparatus D having the relationship of being linked directly in the power transmission, in spite of being via the electric motor side power trans-

mission system, the engine E/G and the generator G have the relationship of being indirectly linked to each other and to the differential apparatus D via the differential gear mechanism P in the power transmission. As a result, by adjusting the power generation load of the generator G relative to the ring gear 23 that receives the traveling load of the vehicle via the differential apparatus D, traveling becomes possible in which the proportion of the output from the engine that is used for driving force and the proportion of the output of the engine that is used for energy generation (i.e. charging the battery) have been suitably adjusted. Moreover, by driving the generator G as an electric motor, the reaction force that acts on the carrier 21 is inverted, therefore, by anchoring the carrier 21 on the drive apparatus casing at that time using some appropriate unillustrated means, the output of the generator G can be transmitted to the ring gear 23 and strengthening of the drive force (parallel mode travel) when the vehicle starts to move using the simultaneous outputs of the electric motor M and the generator G becomes possible.

[0068] Next, the description will be given of the altering of the engine side gear ratio, which is the subject of the present invention. As can be seen from the actual relationships of the axis position and the gear meshing shown in Fig. 2, the diff ring gear 49 and the counter drive gear 41 having a predetermined gear ratio are formed separately from the electric motor side power transmission system formed from the diff ring gear 49 and the output gear 45 having another predetermined gear ratio in the same way. If the diameter of the counter drive gear 41 is altered in response to a request to alter a gear ratio, the axial position of the idle gear 42 that meshes with this needs to be altered. However, there is no need to alter either the diameter or the axial position of the other gears.

[0069] In this way, according to this drive apparatus, the output on the engine E/G side and the output on the electric motor M side are completely independent. It is, thus, possible to freely set the total gear ratio on the engine side. When the setting is being made, there is no change in the distance between the axes of each of the main gears and it is possible to standardize the casing.

[0070] Moreover, according to this drive apparatus, there is no merging of the power transmitted via the engine side power transmission system and the electric motor side power transmission system before the differential apparatus. It is, thus, easy to pinpoint the noise generating portion when gear noise that needs to be reduced is generated.

[0071] Next, Figs. 3 and 4 show the second embodiment, in which the proposals of the present invention have been embodied in another form, in the same technique as in the first embodiment. In this form, the power transmission elements of the engine side power transmission system form a counter reduction gear mechanism comprising a counter drive gear 41 linked to a ring gear 23, a counter driven gear 43 that meshes with the

counter drive gear 41, and a pinion gear 44 that is linked to the counter driven gear 43 and that meshes with the diff ring gear 49. In contrast, a coaxial reduction mechanism R is inserted in the power transmission system on the electric motor side. There is no particular specific structure illustrated for the coaxial reduction mechanism R, however, an optional coaxial reduction mechanism such as is typified by a planetary gear set is used. In this case, the input element of the coaxial reduction mechanism R is connected to a rotor shaft 51 and the shaft 52 that is linked to the output element of the coaxial reduction mechanism R is linked with an output gear 45 that meshes with the diff ring gear 49. As a result, the power transmission elements of the electric motor side power transmission system in this case include the coaxial reduction mechanism R and the output gear 45. The rest of the structure is substantially the same as in the first embodiment and, therefore, in the following description, the relevant elements are given the same reference symbols. Note that this point applies for all of the embodiments described below.

[0072] In the above form, the gear pair formed from the counter driven gear 43 and the counter drive gear 41, which have a predetermined gear ratio, are formed separately from the gear pair formed from the diff ring gear 49 and the pinion gear 45, which have another predetermined gear ratio in the same way. If the diameter of the counter drive gear 41 is altered in response to a request to alter a gear ratio, the diameter of the counter driven gear 43 that meshes with this needs to be altered. There is, however, no need to alter the diameters of the other gears. Moreover, in this case as well, as this gear ratio alteration does not affect any of the other gear pairs, the position of the counter reduction shaft is unchanged. Furthermore, in this case, by altering the reduction ratio of the coaxial reduction mechanism R placed on the electric motor side power transmission system, the gear ratio on the electric motor side can be freely set without the diameter and axial positions of the other gears being altered. As a result, the same effects as in the first embodiment can be achieved with this drive apparatus.

[0073] Note that, if there is no assumption that there will be an alteration of the gear ratio on the electric motor side, it is possible to simplify the power transmission system on the electric motor side. Fig. 5 is a skeleton view of a case such as this showing the structure of the power train of the third embodiment. The axial positional relationships in this form are exactly the same as those for the second embodiment and can be illustrated by referring to Fig. 4. In this form, the coaxial reduction mechanism R of the electric motor side power transmission system is eliminated. The rest of the structure is the same as in the second embodiment.

[0074] Next, Figs. 6 and 7 show the fourth embodiment in the same technique as in the first embodiment. In this form, a structure is employed in which the transmission elements of the engine side power transmission

system is composed of the counter drive gear 41 and the idle gear 42, in the same way as in the first embodiment, and a coaxial reduction mechanism R is inserted between the counter drive gear 41 and the ring gear 23 as an output element of the differential gear mechanism P. The same apparatus as is used for the coaxial reduction mechanism on the electric motor side in the second embodiment can be used for this coaxial reduction mechanism R. In addition, the electric motor side power transmission system is the same as that used in the second embodiment.

[0075] When this type of structure is employed, it is possible to alter the gear ratio on the engine side without affecting the gear ratio on the electric motor side, by altering the reduction ratio of the coaxial reduction mechanism R inserted between the ring gear 23 and the counter drive gear 41 and without needing to alter the meshing diameter of the idle gear 42 and the counter drive gear 41, as in the first embodiment. The complete reverse of this can also be applied to the gear ratio on the electric motor side.

[0076] Next, Figs. 8 and 9 show the fifth embodiment in the same technique as in the first embodiment. In this form, a structure is employed in which the transmission elements of the engine side power transmission system form a counter reduction gear mechanism composed of a counter drive gear 41, a counter driven gear 43 that meshes with the counter drive gear 41, and a pinion gear 44 that is linked to the counter driven gear 43 and meshes with a diff ring gear 49. The transmission elements of the electric motor side power transmission system form a counter reduction gear mechanism composed of an electric motor output gear 45 fixed to a rotor shaft 51, a counter driven gear 47 that meshes with the electric motor output gear 45, and a pinion gear 48 that is linked to the counter driven gear 47 and meshes with a diff ring gear 49.

[0077] When this type of structure is employed, it is possible to alter the gear ratio on the engine side by altering the meshing diameter of the counter drive gear 41 and the counter driven gear 43 and to alter the gear ratio on the electric motor side by altering the meshing diameter of the output gear 46 and the counter driven gear 47 without affecting the mutual gear ratio between the two.

[0078] Next, Figs. 10 and 11 show the sixth embodiment in the same technique as in the first embodiment. In this form, a structure is employed in which the power transmission elements of the engine side power transmission system in the fifth embodiment are replaced by the power transmission elements of the engine side power transmission system in the previous fourth embodiment, namely, a structure in which a coaxial reduction mechanism R is inserted between the counter drive gear 41 and the ring gear 23 as an output element of the differential gear mechanism P. As a result, the power transmission elements of the engine side power transmission system in this case is composed of the three

elements of the coaxial reduction mechanism R, the counter drive gear 41, and the idle gear 42.

[0079] When this type of structure is employed, it is possible to alter the gear ratio on the engine side by altering reduction ratio of the coaxial reduction mechanism R or by altering the diameter of the counter drive gear 41 relative to the diff ring gear 49 or by altering both of these. It is further possible to alter the gear ratio on the electric motor side by altering the meshing diameter of the electric motor output gear 45 and the counter driven gear 47 without affecting the mutual gear ratio between the two.

[0080] Next, Fig. 12 shows the seventh embodiment in the same skeleton view as in the first embodiment. Because the axial positional relationships in this form are exactly the same as those in the sixth embodiment, they can be illustrated by referring to Fig. 11. In this form, in contrast to the sixth embodiment, a structure is employed in which the coaxial reduction mechanism R that was inserted between the counter drive gear 41 and the ring gear 23 as an output element of the differential gear mechanism P is eliminated.

[0081] When this type of structure is employed, it is possible to alter the gear ratio on the engine side by altering the diameter of the counter drive gear 41 relative to the diff ring gear 49 and to alter the gear ratio on the electric motor side by altering the meshing diameter of the counter driven gear 47 and the electric motor output gear 45 without affecting the mutual gear ratio between the two.

[0082] It should be noted that in each of the above embodiments, while the engine side power transmission system and the electric motor side power transmission system are formed as separate systems, a form is employed in which they ultimately merge on the power transmission flow at the common diff ring gear 49. However, it is also possible to separate this ultimate merging section as a possible gear noise counter measure. Three examples of the embodiment in this case will be hereinafter described.

[0083] In the eighth embodiment, power train structure of which is shown in skeleton view in Fig. 13, in the same train structure as in the fifth embodiment shown in Figs. 8 and 9, the diff ring gear 49 of the differential apparatus D is formed from a first and second diff ring gear 49A and 49B. The engine side power transmission system is formed from power transmission elements in which the first diff ring gear 49A is drive linked with the output element 23 of the differential gear mechanism P. Meanwhile the electric motor side power transmission system is formed from power transmission elements in which the second diff ring gear 49B is drive linked with the rotor shaft 51 of the electric motor M.

[0084] When this type of structure is employed, it is possible to make each of the meshings of the meshing portions of all the power transmission elements throughout the entire power train be meshings between different pairs of gears. The frequency of the noise that is gener-

ated by each meshing portion is different, resulting in counter measures against generated noise that needs to be reduced being made even simpler.

[0085] Next, in the ninth embodiment, whose power train structure is shown in skeleton view in Fig. 14, in the same train structure as in the sixth embodiment shown in Figs. 10 and 11, in the same way, the diff ring gear is formed from a first and second diff ring gear 49A and 49B, the first diff ring gear 49A is drive linked by the idle gear 42 with the output element 23 of the differential gear mechanism P, and the second diff ring gear 49B is drive linked with the rotor shaft 51 of the electric motor M by a counter reduction gear mechanism.

[0086] In the same way, in the tenth embodiment, the power train structure of which is shown in skeleton view in Fig. 15, in the same train structure as in the seventh embodiment shown in Fig. 12, the same alterations as described in the above two embodiments are implemented in the diff ring gear.

[0087] In each of the above embodiments, the engine side power transmission system and the electric motor side power transmission system were formed as separate systems in order to simplify the alteration of the gear ratio on the engine side and to simplify the implement of measures against gear noise. However, if simplifying the alteration of the gear ratio is prioritized, it is possible to employ a structure in which one power transmission system is drive linked to the differential apparatus via the other power transmission system. As an example of the employing of this type of structure, a series of embodiments will now be described with respect to the structure employed for drive linking the electric motor side power transmission system to the differential apparatus via the engine side power transmission system.

[0088] Firstly, the hybrid drive apparatus of the eleventh embodiment that is shown in skeleton view in Fig. 16 is provided with an engine E/G, a generator G, a differential gear mechanism P that links the engine E/G and the generator G, an electric motor M, and a differential apparatus D, in the same way as in each of the above embodiments. The basic structure is formed by drive linking the output element of the differential gear mechanism P to the differential apparatus D via the engine side power transmission system, and drive linking the electric motor M to the differential apparatus D via the electric motor side power transmission system. Moreover, the drive apparatus in this case as well is a transverse type drive apparatus for a front engine front drive (FF) vehicle or rear engine rear drive (RR) vehicle in which the engine E/G, the generator G, and the differential apparatus P are placed on a common axis, while the electric motor M and the output shaft of the differential apparatus D are placed on different axes respectively that are parallel with the above common axis.

[0089] This drive apparatus is identical in that it is composed of an electric motor side power transmission system that links the electric motor M with the differential apparatus D, and an engine side power transmission

system that links the differential apparatus D with the output element of the differential gear mechanism P including a single pinion structure planetary gear set. However, in the case of this apparatus, the electric motor side power transmission system is linked to the differential apparatus via the engine side power transmission system. Specifically, the engine side power transmission system is formed from power transmission elements that drive link the output element 23 of the differential gear mechanism P with the diff ring gear 49 of the differential apparatus D, while the electric motor side power transmission system is formed from power transmission elements that drive link the rotor shaft 51 of the electric motor M with the output element 23 of the differential gear mechanism P.

[0090] In the engine side power transmission system in this form, the power transmission elements are formed from the counter drive gear 41 linked to a ring gear 23 as an output element of the differential gear mechanism P and the idle gear 42 drive linked to the counter drive gear 41 and the diff ring gear 49. In the electric motor side power transmission system, the power transmission elements are formed from the electric motor output gear 45 fixed to the rotor shaft 51 of the electric motor M, and the idle gear 46 drive linked to the electric motor output gear 45 and the counter drive gear 41.

[0091] In the state where this type of structure is employed, the gear ratios can be selected and altered on both the engine side and the electric motor side while merging the engine side power transmission system and the electric motor side power transmission system together by the power transmission elements between each of the axes of the engine and generator, the electric motor and the differential apparatus. Accordingly there is no need to alter the position of the main axes. As a result, the casings before the alteration of the gear ratio setting and after the alteration of the gear ratio setting can be standardized. This point is the same for each of the series of embodiments that follow.

[0092] In the twelfth embodiment shown in skeleton view in Fig. 17, a counter reduction gear mechanism is used instead of the idle gear 46 of the electric motor side power transmission system of the eleventh embodiment.

[0093] In the thirteenth embodiment shown in skeleton view in Fig. 18, a counter reduction gear mechanism is used instead of the idle gear 42 of the engine side power transmission system of the eleventh embodiment.

[0094] In the fourteenth embodiment shown in skeleton view in Fig. 19, counter reduction gear mechanisms are used instead of the idle gears of both the engine side power transmission system and the electric motor side power transmission system.

[0095] In the fifteenth embodiment shown in skeleton view in Fig. 20, the point of the embodiment is different to the modifications of the previous three embodiments

and a split structure for the counter ring gear 41 is employed for the same reasons as for the diff ring gear 49 previously. In this case, the engine side power transmission system is formed from a first counter drive gear 41A linked with the output element 23 of the differential gear mechanism P, and a power transmission element, namely, the idle gear 42 drive linking the counter drive gear 41A with the diff ring gear 49. The electric motor side power transmission system is formed from a the electric motor output gear 45 fixed to the rotor shaft 51 of the electric motor M, and a power transmission element, namely, the idle gear 46 that drives and links the electric motor output gear 45 and a second counter drive gear 41B linked with the output element 23 of the differential gear mechanism P.

[0096] In the sixteenth embodiment shown in skeleton view in Fig. 21, both the idle gear of the engine side power transmission system and the idle gear of the electric motor side power transmission system in the fifteenth embodiment are replaced by a counter reduction gear mechanism.

[0097] In the seventeenth embodiment shown in skeleton view in Fig. 22, the electric motor side power transmission system is formed from a chain transmission mechanism serving as a unidirectional rotation transmission mechanism. The power transmission elements in this case is composed of a sprocket 71 fixed to the rotor shaft 51 of the electric motor M, a sprocket 73 linked with the output element 23 of the differential gear mechanism P, and a chain 72 entrained between both sprockets.

[0098] The eighteenth embodiment, which is shown in skeleton view in Fig. 23, is the seventeenth embodiment in which the coaxial reduction apparatus R is inserted in the electric motor side power transmission system, and the counter reduction gear mechanism of the engine side power transmission system is replaced with the idle gear 42.

[0099] Next, as another example of a structure in which one power transmission system is drive linked to the differential apparatus via the other power transmission system, a description will be given of a series of embodiments that employ a structure where the engine side power transmission system is drive linked to the differential apparatus via the electric motor power transmission system.

[0100] Firstly, Figs. 24 and 25 show a skeleton view expanded between the axes of a power train of the hybrid drive apparatus of the nineteenth embodiment and a view of the gear meshing in the drive apparatus as seen from the axial direction. The basic structure of this apparatus is the same as that of each of the above embodiments and this apparatus also is provided with an engine E/G, a generator G, a differential gear mechanism P linking the engine E/G and the generator G, an electric motor M, and a differential apparatus D. Moreover, in this drive apparatus, the engine side power transmission system, in which the output element of a

differential gear mechanism P including a single pinion structure planetary gear set is drive linked to the differential apparatus D, is linked to the differential apparatus D via the electric motor power transmission system linking the electric motor M with the differential apparatus D.

[0101] The power transmission elements of the electric motor side power transmission system in the present embodiment is composed of the electric motor output gear 45 fixed to the rotor shaft 51, the idle gear 46 that meshes with the electric motor output gear 45 and the diff ring gear 49. The power transmission elements of the engine side power transmission system is composed of the counter drive gear 41 linked with the ring gear 23 of the differential gear mechanism P and the idle gear 42 that meshes with the counter drive gear 41 and the motor output gear 45.

[0102] In the case where this type of structure is employed, as is shown by the actual relationship between the axial positions and the gear meshing shown in Fig. 25, the total gear ratio on the engine side is determined by the gear ratio between the electric motor output gear 45 and the counter drive gear 41 having a predetermined gear ratio, and the gear ratio between the electric motor output gear 45 and the diff ring gear 49, namely, the electric-motor side gear ratio. However, when altering total gear ratio on the engine side only, this can be accomplished by altering the diameter of the counter drive gear 41, and by dealing with the resulting change in the gap between the electric motor output gear 45 and the counter drive gear 41, which changes as a result of the above altering of the diameter, by shifting the axial position of the idle gear 42. Moreover, when altering the gear ratio on the electric motor side as well, this can be accomplished by altering the diameter of the electric motor output gear 45 and dealing with the resulting change in the gap between the electric motor output gear 45 and the diff ring gear 49 and in the gap between the electric motor output gear 45 and the counter drive gear 49 by shifting the axial positions of the idle gears 46 and 42, respectively. If the diameter of any one of the counter drive gear 41, the electric motor output gear 45, and the diff ring gear 49 is to be altered in this way, as well as if the diameters of any combination of these is to be altered, this can be dealt with by shifting the axial positions of both the idle gears.

[0103] Thus, according to this drive apparatus, it is possible to alter the total gear ratio on the engine side and, if necessary, to also alter the gear ratio on the electric motor side with the positions of the three main axes, where the engine E/G, the electric motor M, and the differential apparatus D are placed and fixed.

Accordingly demands for the alteration of each gear ratio can be met without there needing to be any major alteration in the drive apparatus casing. Further, particularly when idle gears are used in both power transmission systems, because it is possible to place all the power transmission elements together within the same plane, the advantage of the more compact size of the

drive apparatus can be obtained.

[0104] Next, Figs. 26 and 27 show the twentieth embodiment. In this embodiment, the power transmission elements of the engine side power transmission system are the same as those of the above nineteenth embodiment with only the power transmission element of the electric motor side power transmission system being altered to a counter gear mechanism having a reduction function. The counter reduction gear mechanism in this form is composed of the electric motor output gear 45 fixed to the rotor shaft 51 of the electric motor M, the counter driven gear 47 that meshes with the electric motor output gear 45, and the pinion gear 48 that is linked with the counter driven gear 47 and meshes with the diff ring gear 49.

[0105] In the case where this type of form is employed, referring now to the relationship between the actual axial positions and the power transmission elements shown in Fig. 27, it is possible to alter the total gear ratio on the engine side by altering the gear ratio of the electric motor side power transmission system. The elements altered in this case are the diametric ratio of the counter driven gear 47 to the electric motor output gear 45, or the diametric ratio of the diff ring gear 49 to the pinion gear 48. It is necessary to shift the axial position of the idle gear 42 only when altering the diameter of the electric motor output gear 25.

[0106] In the twenty-first embodiment shown in skeleton view in Fig. 28, the power transmission elements of the engine side power transmission system are altered to a counter reduction gear mechanism, which is the opposite to the twentieth embodiment.

[0107] Next, Fig. 29 shows the twenty-second embodiment in which the electric motor output gear is formed with a split structure for the same reasons as pertained to the fifteenth embodiment shown in Figs. 20 and 21. In this form, using the previous nineteenth embodiment as the basic structure, the idle gear 42 of the engine side power transmission system meshes with one electric motor output gear, 45B, fixed to the rotor shaft 51 of the electric motor M, while the other electric motor output gear, 45B, meshes with the diff ring gear 49 via the idle gear 46.

[0108] In the case where this type of form is employed, it becomes possible to separately alter the meshing diameters of the electric motor output gears relative to the counter drive gear 41 and the diff ring gear 49. This makes it possible to simply alter the gear ratios of both the engine side power transmission system and the electric motor side power transmission system.

[0109] In the twenty-third embodiment shown in Fig. 30, the idle gear of the electric motor side power transmission system of the twenty-second embodiment is changed to a counter reduction gear mechanism.

[0110] Fig. 31 shows the twenty-fourth embodiment which is the twenty-second embodiment reduced to its simplest form. In this form, a structure is employed in which the engine side power transmission system and

the electric motor side power transmission system are directly drive linked without interposing any intermediate transmission elements between the two. Namely, the counter drive gear 41 that forms the engine side power transmission system meshes with the electric motor output gear 45B fixed to the rotor shaft 51 of the electric motor M, while the electric motor output gear 45A that forms the electric motor side power transmission system meshes with the diff ring gear 49.

[0111] Even when this type of form is employed, it is possible to alter the total gear ratio on the engine side by altering the meshing diametric ratio of the counter drive gear and the electric motor output gear without affecting the gear ratio on the electric motor side.

[0112] Next, Figs. 32 and 33 show the twenty-fifth embodiment in which the transmission means of the engine side power transmission system in the twenty-second embodiment is changed to a chain transmission mechanism. Specifically, the chain transmission mechanism includes a sprocket 71 linked with the ring gear 23 of the differential gear mechanism P, a sprocket 73 fixed to the rotor shaft 51 of the electric motor M, and a chain 72 entrained between the sprockets 71 and 73.

[0113] In the case where this type of form is employed, referring now to the relationship between the actual axial positions and the transmission means shown in Fig. 33, the total gear ratio on the engine side is decided by the gear ratio determined by the diametric difference between the two sprockets 71 and 73 that have a predetermined reduction ratio, and the gear ratio of the electric motor output gear 45 and the diff ring gear 49, namely, the gear ratio on the electric motor side. In this form, only when altering the total gear ratio on the engine side, this can be dealt with simply by altering the diametric difference between the sprockets 71 and 73 without all the axial positions being shifted. Moreover, when altering the gear ratio on the electric motor side as well, the description given for the nineteenth embodiment applies. Thus, in this embodiment as well, it is possible to deal with demands for the alteration of each reduction ratio in the same way as in the nineteenth embodiment without needing to perform any major alteration in the drive apparatus casing. In particular, when altering the total gear ratio of an engine whose practical requirements are high, this can be dealt with using an unchanged standardized gearbox casing.

[0114] Next, Figs. 34 and 35 show the twenty-sixth embodiment. In this embodiment, the power transmission elements of the engine side power transmission system are the same as those of the above twenty-fifth embodiment, and the power transmission elements of the electric motor side power transmission system are the same as those of the twentieth embodiment.

[0115] In the case where this type of form is employed, referring now to the relationship between the actual axial positions and the power transmission elements shown in Fig. 35, it is possible to respectively deal with alterations to the total gear ratio on the engine side

by altering the sprocket diameter and with alterations to the gear ratio on the electric motor side by altering the diametric relationship of the electric motor output gear 45 to the counter driven gear 47 with absolutely no alteration of the axial positions.

[0116] The above descriptions have been given only for a transverse type drive apparatus for an FF vehicle or an RR vehicle with each of the embodiments of the present invention placed in one of three groups. However, the present invention can also be embodied in the form of a front engine rear drive (FR) type longitudinal drive apparatus. In the case where this embodiment is employed, the apparatus is composed of an engine, a generator, a differential gear mechanism linking the engine and the generator, and an electric motor. The basic structure is composed of the output elements of the differential gear mechanism being drive linked to the vehicle wheels via the engine side power transmission system, and the electric motor being drive linked to the vehicle wheels via the electric motor side power transmission system. Moreover, this drive apparatus is provided with output shafts drive linking each of the above power transmission systems and vehicle wheels. The engine side power transmission system is formed from power transmission elements linking the output element of the differential gear mechanism with the first output gear fixed to an output shaft. The electric motor side power transmission system is formed from power transmission elements linking the rotor shaft of the electric motor with the second output gear fixed to an output shaft.

[0117] If this type of form is used, referring now to Figs. 13 and 14, although the specific structure is not illustrated, it is clearly obvious that an output shaft has replaced the differential apparatus and an output shaft has replaced the diff ring gear of the ninth and tenth embodiments.

[0118] In this format as well, in the same way as in the above second group of embodiments, a structure is employed in which the engine side power transmission system is formed from power transmission elements that drive link, via the output shaft, the vehicle wheel and the first counter drive gear linked to an output element of the differential gear mechanism, and the electric motor side power transmission system is formed from power transmission elements that drive link the electric motor output gear fixed to the rotor shaft of the electric motor and the second counter drive gear that is linked with an output element of the differential gear mechanism. The electric motor side power transmission system is thus drive linked to the vehicle wheels via the engine side power transmission system.

[0119] In this case as well, referring now to Figs. 20 and 21, although the specific structure is not illustrated, it is clearly obvious that an output shaft has replaced the differential apparatus of each of the embodiments.

[0120] Further, in the same way as in the above third group of embodiments, a structure is employed in which the electric motor side power transmission system is

formed from power transmission elements drive linking the vehicle wheels with the first electric motor output gear fixed to the rotor shaft of the electric motor, and the engine side power transmission system is formed from power transmission elements drive linking the output element of the differential gear mechanism and the second electric motor output gear fixed to the rotor shaft of the electric motor. The engine side power transmission system is thus drive linked to the vehicle wheels via the electric motor side power transmission system.

[0121] In this case as well, referring now to Figs. 29 to 31 although the specific structure is not illustrated, it is clearly obvious that an output shaft has replaced the differential apparatus of each of the embodiments.

[0122] In the structure according to the first aspect of the invention, the power transmission by the power transmission system on the engine and generator side from the engine to the differential apparatus, and the power transmission by the power transmission system on the electric motor side from the electric motor to the differential apparatus are carried out separately on the respective transmission paths. It is possible to make the outputs from engine side and from the electric motor side completely independent of each other, and for the total gear ratios on both sides down to the differential apparatus to be set freely. Moreover, because both power transmission paths are independent of each other, noise reduction measures taken when gear noise that needs to be reduced is generated are simplified.

[0123] In the structure according to a preferred form of the first aspect of the invention, alterations of the gear ratio settings on both the engine and electric motor sides can be dealt with through the power transmission elements between each of the axes of the engine and generator, electric motor, and differential apparatus, there is no need for the positions of the main axes to be altered, resulting in the casing being the same both before and after alteration of the gear setting.

[0124] Further, in the structure according to another preferred form of the first aspect of the invention, the power transmission paths of both the engine side and the electric motor side that are formed independently include the input sections to the differential apparatus, further simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0125] Next, in the structure according to the second aspect of the invention, alterations of the gear ratio settings on both the engine and electric motor sides can be dealt with through the power transmission elements between each of the axes of the engine and generator, electric motor, and differential apparatus while causing the power transmission system on the engine side and the power transmission system on the electric motor side to merge together. There is no need for the positions of the main axes to be altered, resulting in the casing being the same both before and after alteration of the gear setting.

[0126] Moreover, in the structures according to a pre-

ferred form of the second aspect of the invention, alterations of the gear ratio settings on both the engine and electric motor sides can be dealt with through the power transmission elements between each of the axes of the engine and generator, electric motor, and differential apparatus. There is no need for the positions of the main axes to be altered, resulting in the casing being the same both before and after alteration of the gear settings.

[0127] Moreover, in the structure according to the preferred form of the second aspect of the invention, the input section to the power transmission path on the engine side from the power transmission path on the electric motor side is a path that is independent from the power transmission path on the engine side, simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0128] Further, in the structure according to the preferred form of the second aspect of the invention, the power transmission path on the electric motor side is not affected by restrictions of the distance between axes that goes together with alterations of the gear ratios, simplifying setting alteration of the total gear ratio on the electric motor side. Moreover, fixing of the total gear ratio on the electric motor side when the total gear ratio on the engine side is altered is also simplified.

[0129] Next, in the structure according to the third aspect of the invention, the flow of the power transmission on the electric motor side is positioned on the downstream side, of the two flows of the power transmission on the engine side and the power transmission on the electric motor side. It is, thus, essentially possible to alter the total gear ratio on the engine and generator side without affecting the total gear ratio of the power transmission system on the electric motor side.

[0130] In the structures according to a preferred form of the third aspect of the invention, alterations of the gear ratio settings on both the engine and electric motor sides can be dealt with through the power transmission elements between each of the axes of the engine and generator, electric motor, and differential apparatus. There is no need for the positions of the main axes to be altered, resulting in the casing being the same both before and after alteration of the gear settings.

[0131] Moreover, in the structure according to the preferred form of the third aspect of the invention, the input section to the power transmission path on the electric motor side from the power transmission path on the engine side becomes a path that is independent from the power transmission path on the electric motor side, simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0132] Moreover, in the structure according to the preferred form of the third aspect of the invention, the power transmission path on the engine side is not affected by restrictions of the distance between axes that goes together with alterations of the gear ratios, simplifying alteration of the total gear ratio on only the engine side.

[0133] In the structure according to the fourth aspect of the invention, the power transmission by the power transmission system on the engine and generator side from the engine to the output shaft, and the power transmission by the power transmission system on the electric motor side from the electric motor to the output shaft are carried out separately on the respective transmission paths. It is, thus, possible to make the outputs from engine side and from the electric motor side completely independent of each other, and for the total gear ratios on both sides down to the output shafts to be set freely. Moreover, both power transmission paths are independent of each other, simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0134] In the structure according to the fifth aspect of the invention, it is possible to form a power transmission system with no simultaneous meshing by performing the power transmission of the power transmission system on the electric motor side via the power transmission system on the engine and generator side, simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0135] In the structure according to the sixth aspect of the invention, it is possible to form a power transmission system with no simultaneous meshing by performing the power transmission of the power transmission system on the engine and generator side via the power transmission system on the electric motor side, simplifying noise reduction measures taken when gear noise that needs to be reduced is generated.

[0136] In the structure according to any one of the first to the sixth aspects of the invention, all of the respective power transmission elements forming the power transmission system on the engine and generator side and the power transmission system on the electric motor side are placed within the same plane. Accordingly this structure is effective when the axial length of the drive apparatus is limited.

[0137] In the structure according to any one of the first to the sixth aspects of the invention, it is possible to alter the total gear ratios on both the engine side and the electric motor side without having to alter the positions of either the main axes or the axes of each of the power transmission elements.

[0138] In the structure according to any one of the first to the sixth aspects of the invention, it is possible to deal flexibly with the axial length of the drive apparatus being limited and with whether or not there needs to be an alteration in the axial positions of the respective power transmission elements due to an alteration of the total gear ratio.

[0139] In the structure according to any one of the first to the sixth aspects of the invention, there is absolutely no need for any alteration in the axial positions of the respective power transmission elements due to an alteration of the total gear ratio.

[0140] The present invention has been described

above by offering a plurality of embodiments thereof, however, these embodiments do not cover the entire scope of the technological ideas of the present invention. The present invention may be implemented by altering the specific structure thereof in a variety of ways within the scope of the description claimed.

[0141] The gear noise reduction measures is simplified as well as the optional setting alteration of the total gear ratio on the engine side is enabled without altering the mutual positions between axes. A hybrid drive apparatus is formed from an engine, a generator, a differential gear mechanism linking the above two, an electric motor, and a differential apparatus. The power transmission system on the side of the engine that links the differential apparatus with the output element of the differential gear mechanism and the power transmission system on the side of the electric motor that links the differential apparatus with the electric motor are each formed from separate power transmission elements and are each linked to the differential apparatus at the most downstream point of the power transmission system of each. As a result, it is possible to arbitrarily alter the setting of the total gear ratio on the engine side simply by altering the meshing diameter of the power transmission elements without altering the mutual positions between the axes of the engine, electric motor, and differential apparatus. Moreover, the implementing of measures against noise is simplified because the upstream side of the power transmission system that has a high probability of being the one generating problem noise is formed separately.

Claims

1. A hybrid drive apparatus comprising:

- an engine;
- a generator;
- a differential gear mechanism linking the engine and the generator;
- an electric motor; and
- a differential apparatus, in which an output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein:
 - the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and
 - the power transmission system on the side of the engine and generator and the power trans-

mission system on the side of the electric motor are each formed from separate power transmission elements, and both are drive linked at the most downstream ends of their respective power transmission systems with the differential apparatus.

2. The hybrid drive apparatus according to claim 1, wherein:

the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and a diff input gear of the differential apparatus, and

the power transmission system on the side of the electric motor is formed from power transmission elements that drive link a rotor shaft of the electric motor and the diff input gear.

3. The hybrid drive apparatus according to claim 1, wherein:

the diff input gear of the differential apparatus comprises a first and a second diff input gear, the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the first diff input gear, and

the power transmission system on the side of the electric motor is formed from power transmission elements that drive link the rotor shaft of the electric motor and the second diff input gear.

4. A hybrid drive apparatus comprising:

an engine;
a generator;
a differential gear mechanism linking the engine and the generator;
an electric motor; and

a differential apparatus, in which an output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein:

the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and

the power transmission system on the side of the electric motor is drive linked to the differential apparatus via the power transmission system on the side of the engine and generator.

5. The hybrid drive apparatus according to claim 4, wherein:

the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the diff input gear of the differential apparatus, and

the power transmission system on the side of the electric motor is formed from power transmission elements that drive link the rotor shaft of the electric motor and the output element of the differential gear mechanism.

6. The hybrid drive apparatus according to claim 5, wherein:

the power transmission system on the side of the engine and generator is formed from a counter drive gear linked to the output element of the differential gear mechanism and power transmission elements that drive link this counter drive gear and the diff input gear, and the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor shaft of the electric motor power transmission elements that drive link this electric motor output gear and the counter drive gear.

7. The hybrid drive apparatus according to claim 5, wherein:

the power transmission system on the side of the engine and generator is formed from a first counter drive gear linked to the output element of the differential gear mechanism and power transmission elements that drive link this first counter drive gear and the diff input gear, and the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor shaft of the electric motor power transmission elements that drive link this electric motor output gear and a second counter drive gear linked to the output element of the differential gear mechanism.

8. The hybrid drive apparatus according to claim 5, wherein the power transmission system on the side of the electric motor comprises a sprocket fixed to the rotor shaft of the electric motor, a sprocket linked

to the output element of the differential gear mechanism, and a chain entrained between the two sprockets.

9. A hybrid drive apparatus comprising:

an engine;
a generator;
a differential gear mechanism linking the engine and the generator;
an electric motor; and
a differential apparatus, in which the output element of the differential gear mechanism is drive linked to the differential apparatus via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the differential apparatus via a power transmission system on the side of the electric motor, wherein:
the engine and the generator and the differential gear mechanism are placed on a common axis and output shafts of the electric motor and the differential apparatus are each placed on their own different axes which are parallel to the common axis, and
the power transmission system on the side of the engine and generator are drive linked to the differential apparatus via the power transmission system on the side of the electric motor.

10. The hybrid drive apparatus according to claim 9, wherein:

the power transmission system on the side of the electric motor is formed from power transmission elements drive linking the rotor shaft of the electric motor and the diff input gear of the differential apparatus, and
the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the rotor shaft of the electric motor.

11. The hybrid drive apparatus according to claim 10, wherein:

the power transmission system on the side of the electric motor is formed from the electric motor output gear fixed to the rotor shaft of the electric motor and power transmission elements drive linking the electric motor output gear and the diff input gear, and
the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the electric motor output gear.

12. The hybrid drive apparatus according to claim 10, wherein:

the power transmission system on the side of the electric motor is formed from the first electric motor output gear fixed to the rotor shaft of the electric motor and power transmission elements drive linking the first electric motor output gear and the diff input gear, and
the power transmission system on the side of the engine and generator is formed from power transmission elements that drive link the output element of the differential gear mechanism and the second electric motor output gear that is fixed to the rotor shaft of the electric motor.

13. The hybrid drive apparatus according to claim 10, wherein the power transmission system on the side of the engine and generator comprises a sprocket linked to the output element of the differential gear mechanism, a sprocket fixed to the rotor shaft of the electric motor, and a chain entrained between the two sprockets.

14. A hybrid drive apparatus comprising:

an engine;
a generator;
a differential gear mechanism linking the engine and the generator; and
an electric motor, in which an output element of the differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein:
the hybrid drive apparatus is provided with output shafts drive linking each of the power transmission systems and the vehicle wheels,
the power transmission system on the side of the engine and generator is formed from power transmission elements drive linking the output element of the differential gear mechanism and a first output gear fixed to an output shaft, and
the power transmission system on the side of the electric motor is formed from power transmission elements drive linking the rotor shaft of the electric motor and a second output gear fixed to an output shaft.

15. A hybrid drive apparatus comprising:

an engine;
a generator;
a differential gear mechanism linking the engine and the generator; and
an electric motor, in which an output element of

the differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein:

the power transmission system on the side of the engine and generator is formed from a first counter drive gear linked to an output element of the differential gear mechanism and power transmission elements drive linking this first counter drive gear and the vehicle wheels, the power transmission system on the side of the electric motor is formed from an electric motor output gear fixed to the rotor of the electric motor and power transmission elements drive linking this electric motor output gear and a second counter drive gear linked to an output element of the differential gear mechanism, and the power transmission system on the side of the electric motor is drive linked to the vehicle wheels via the power transmission system on the side of the engine and generator.

16. A hybrid drive apparatus comprising:

an engine;
a generator;
a differential gear mechanism linking the engine and the generator; and
an electric motor, in which an output element of the differential gear mechanism is drive linked to the vehicle wheels via a power transmission system on the side of the engine and generator, and the electric motor is drive linked to the vehicle wheels via a power transmission system on the side of the electric motor, wherein:
the power transmission system on the side of the electric motor is formed from a first electric motor output gear fixed to the rotor of the electric motor and power transmission elements drive linking the first electric motor output gear and the vehicle wheels,
the power transmission system on the side of the engine and generator is formed from power transmission elements drive linking the output element of the differential gear mechanism and a second electric motor output gear fixed to the rotor shaft of the electric motor, and
the power transmission system on the side of the engine and generator is drive linked to the vehicle wheels via the power transmission system on the side of the electric motor.

17. The hybrid drive apparatus according to any of claims 2, 3, 5 to 8, and 10 to 16, wherein the power transmission element is an idle gear.

18. The hybrid drive apparatus according to any of claims 2, 3, 5 to 8, and 10 to 16, wherein the power transmission element is a counter reduction gear mechanism.

19. The hybrid drive apparatus according to any of claims 2, 3, 5 to 8, and 10 to 16, wherein the power transmission element in one of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor is an idle gear, and the power transmission element in the other of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor is a counter reduction gear mechanism.

20. The hybrid drive apparatus according to any of claims 1 to 16, wherein a coaxial reduction mechanism is inserted in at least one of the power transmission system on the side of the engine and generator and the power transmission system on the side of the electric motor.

FIG. 1

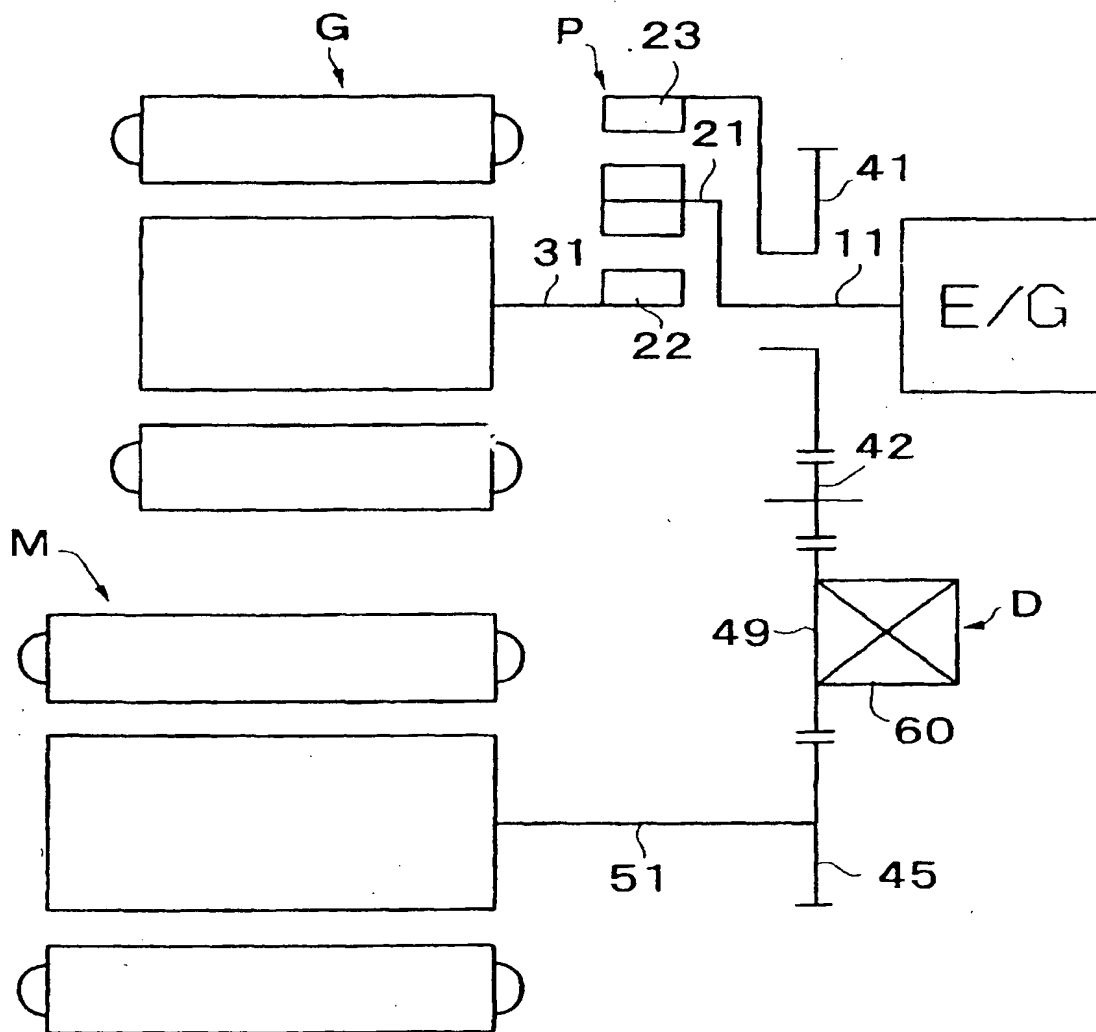


FIG. 2

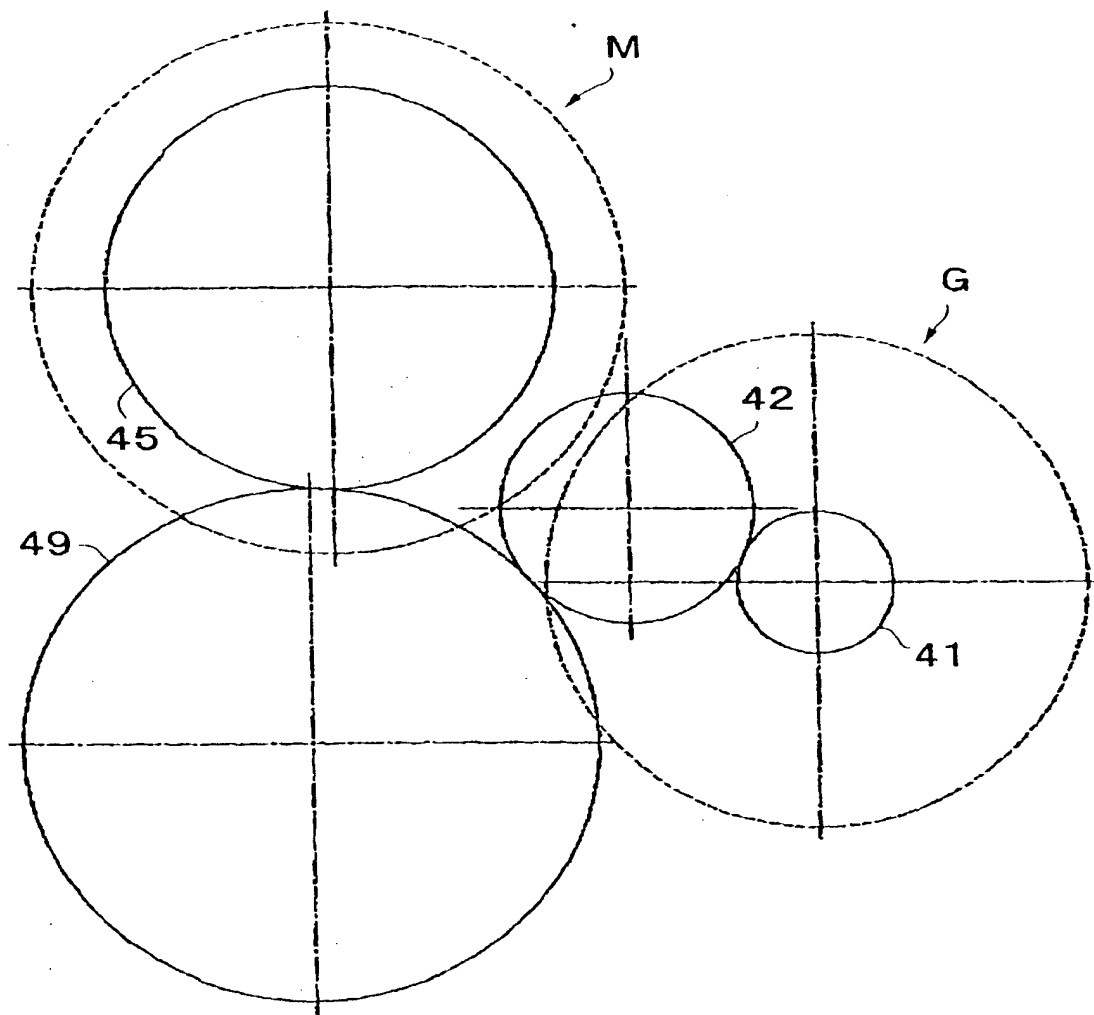


FIG. 3

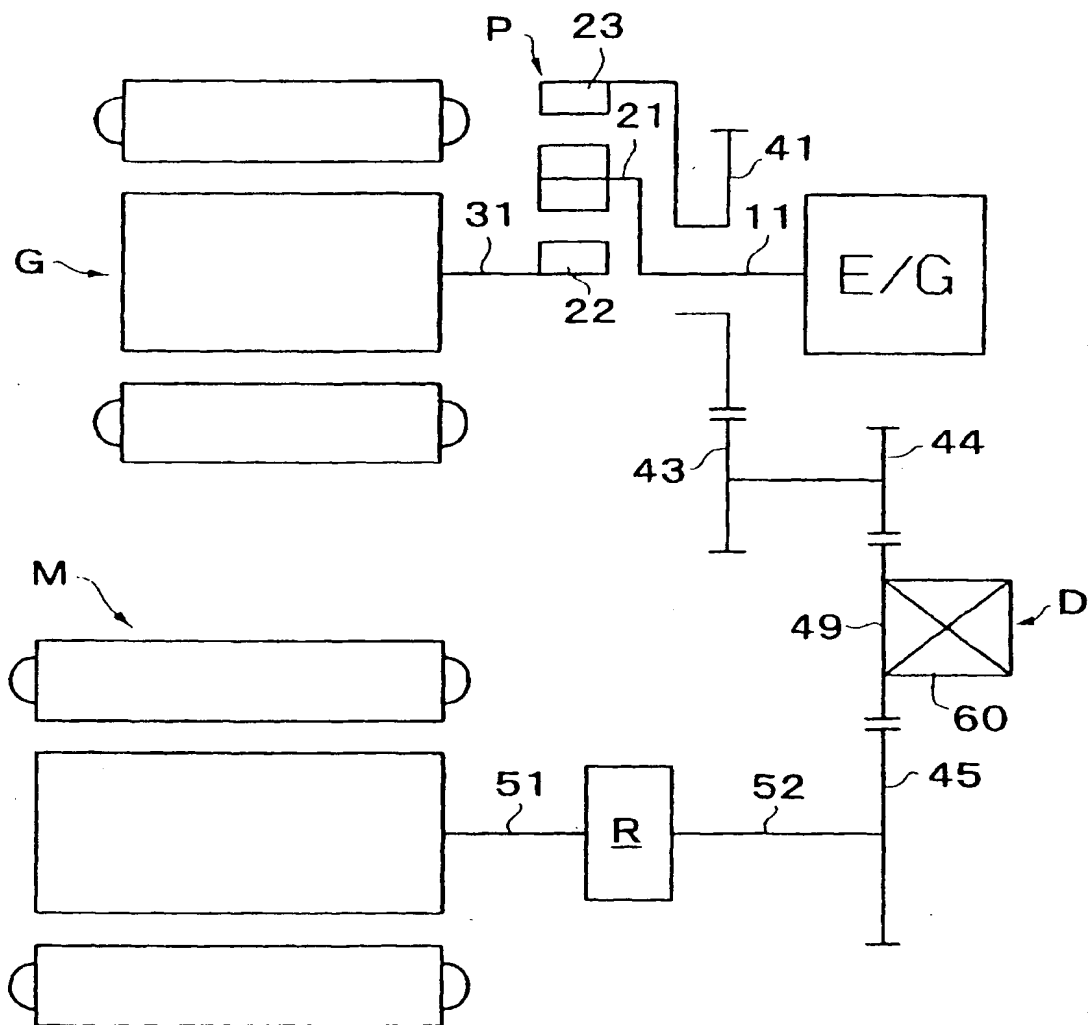


FIG. 4

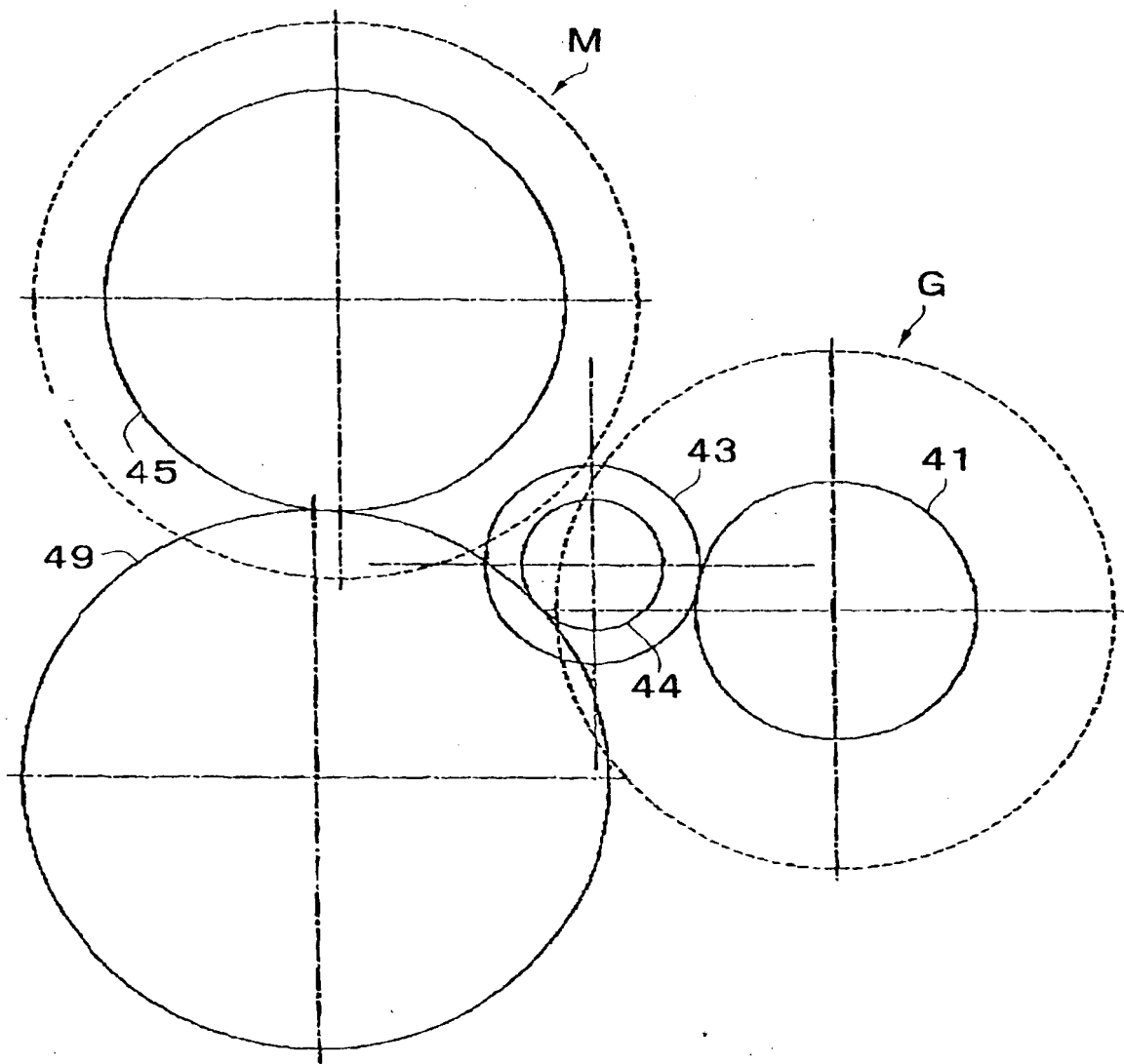


FIG. 5

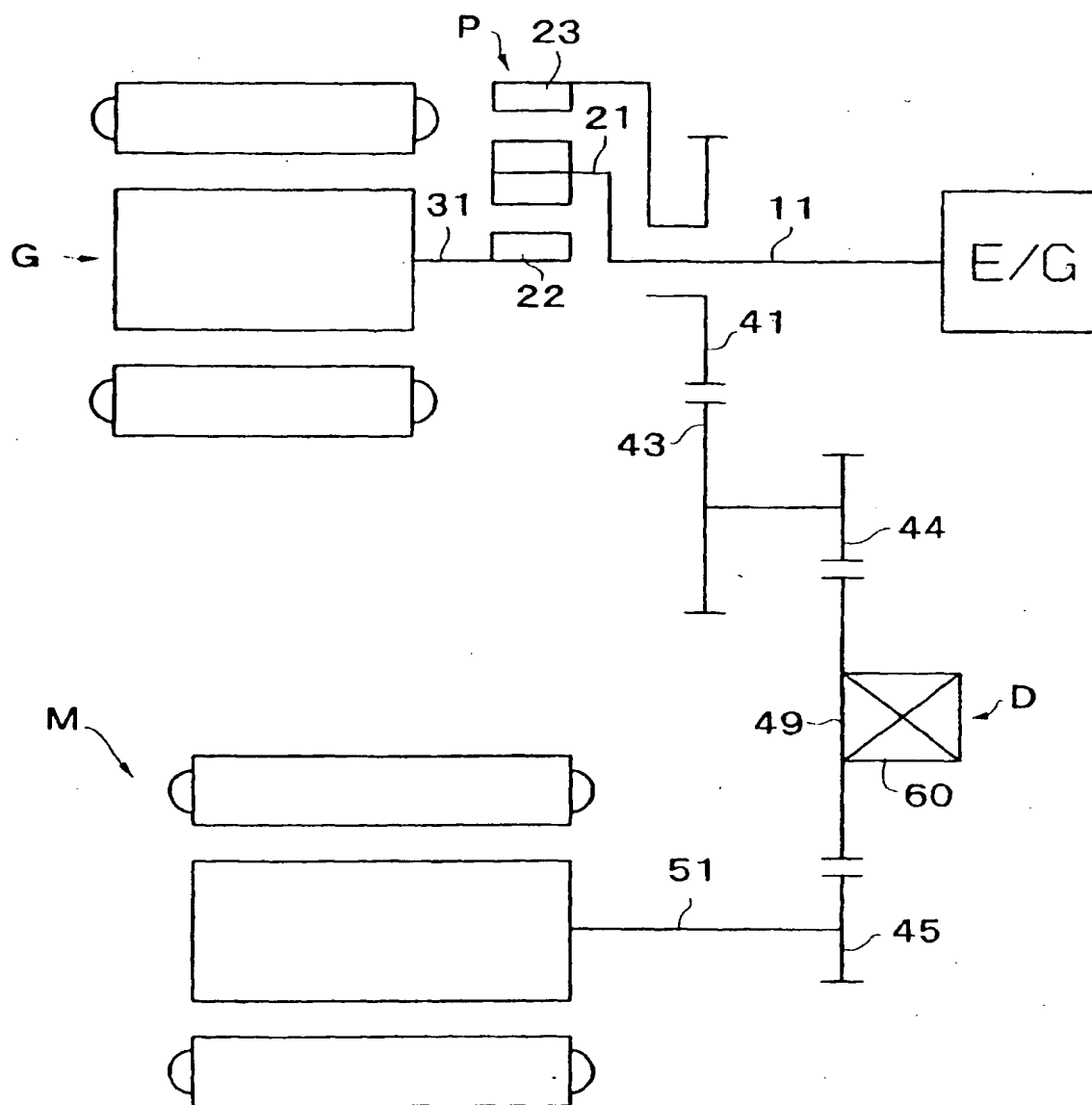


FIG. 6

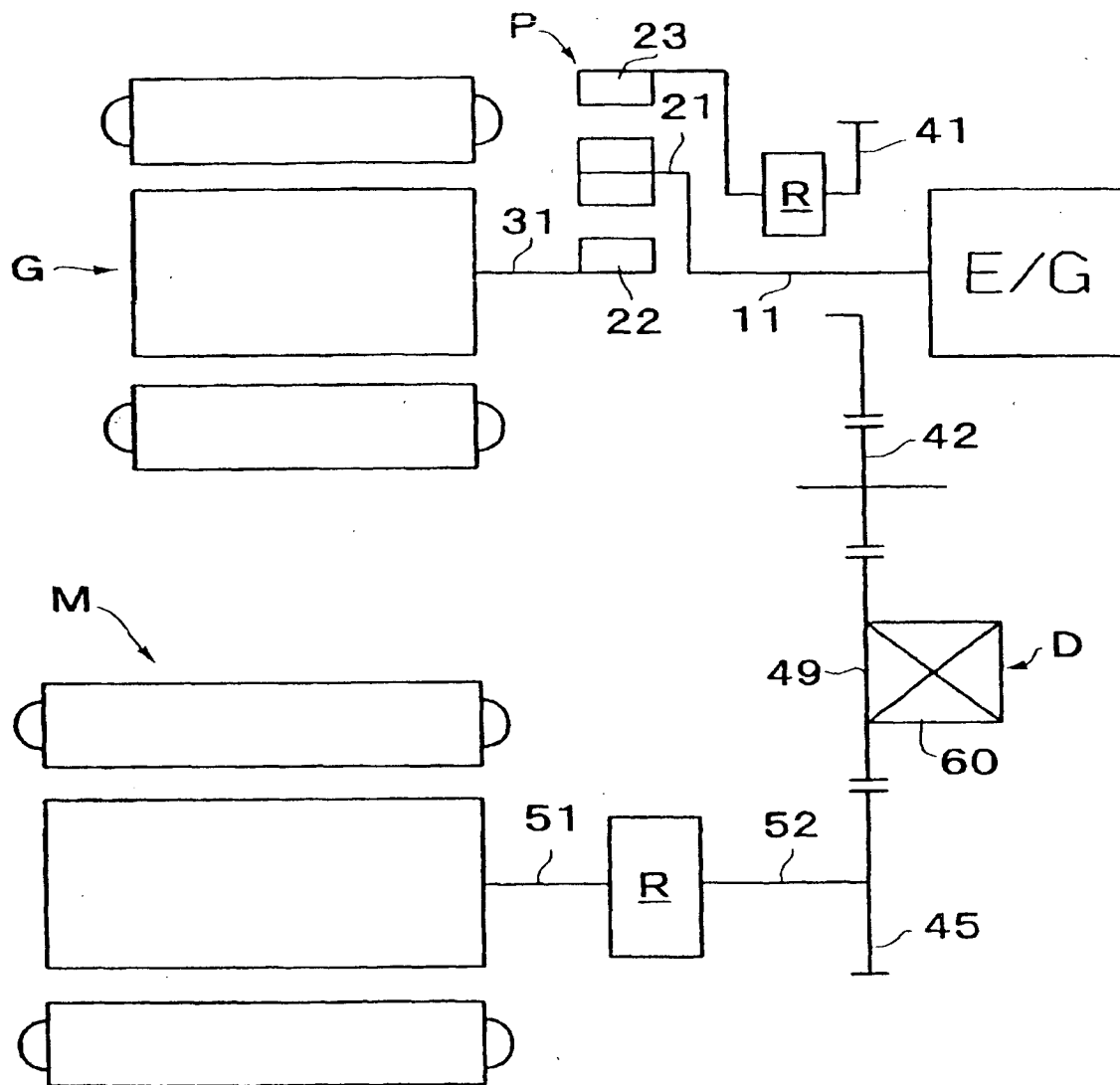


FIG. 7

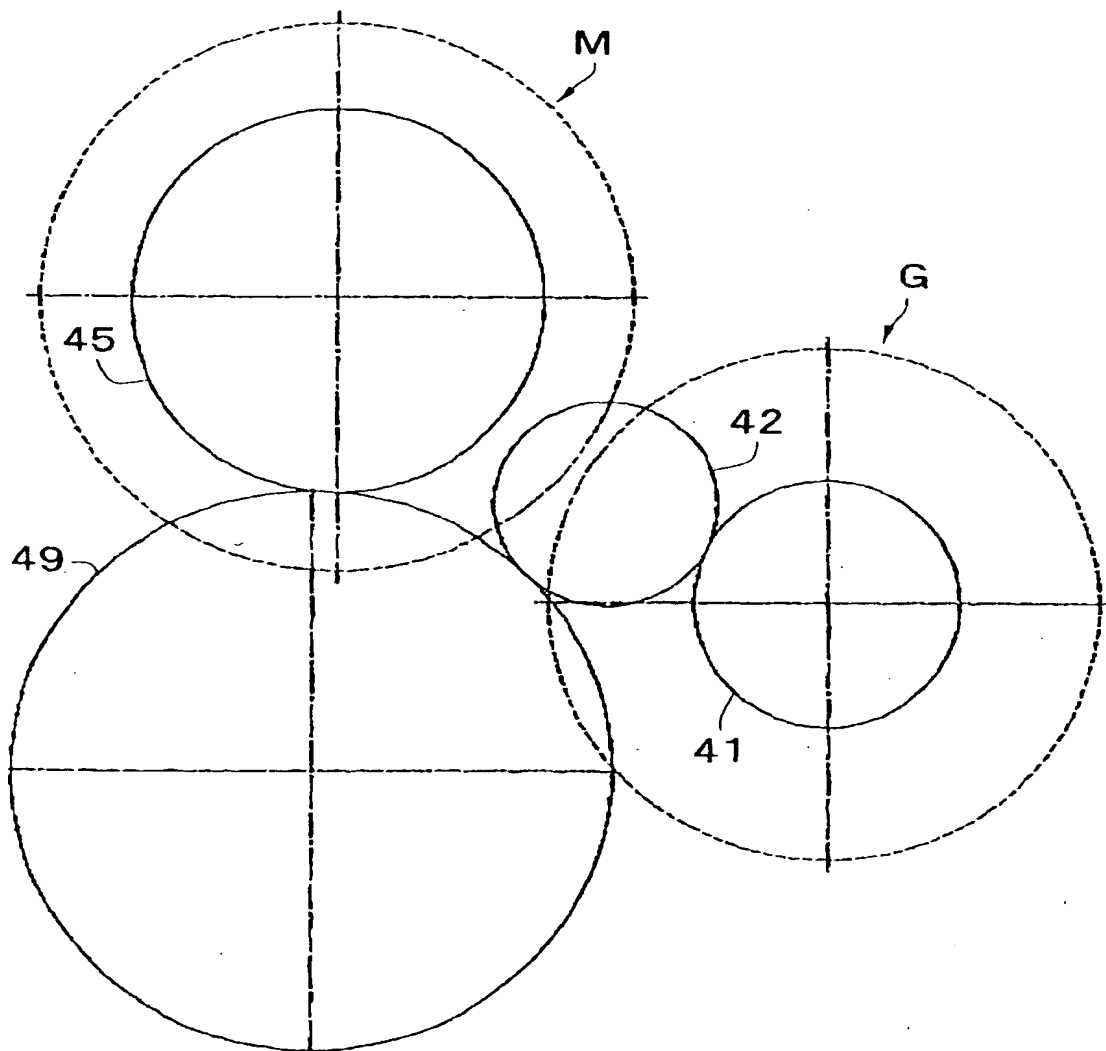


FIG. 8

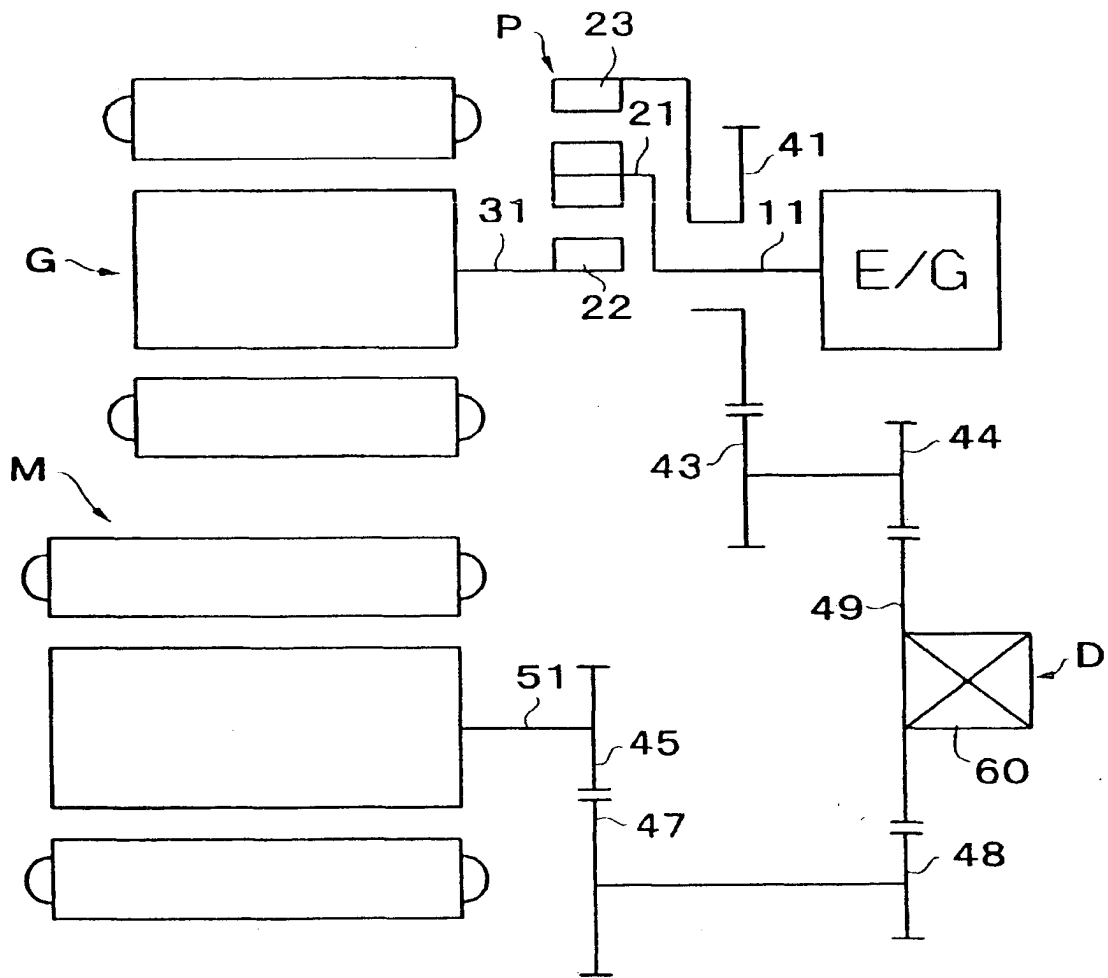


FIG. 9

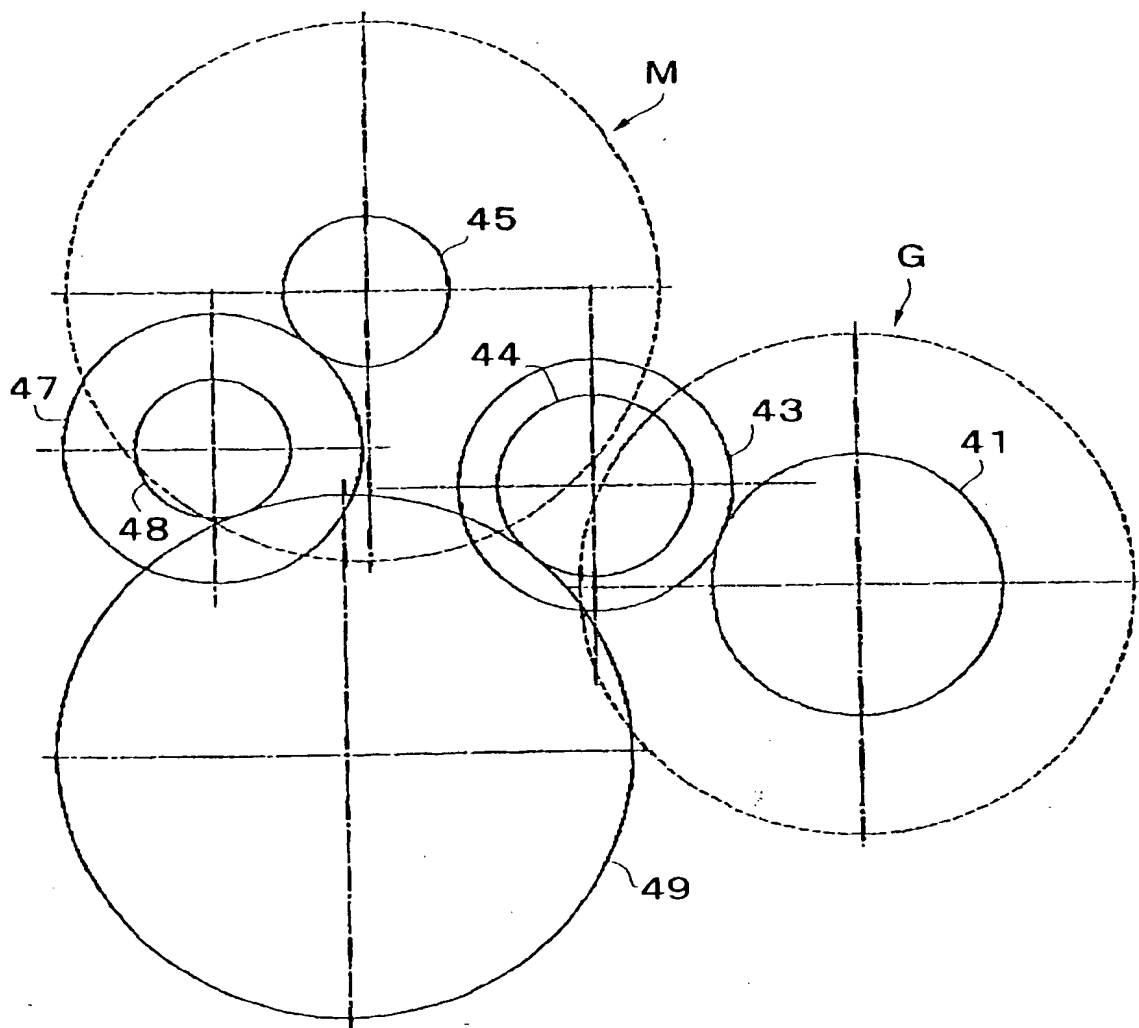


FIG. 10

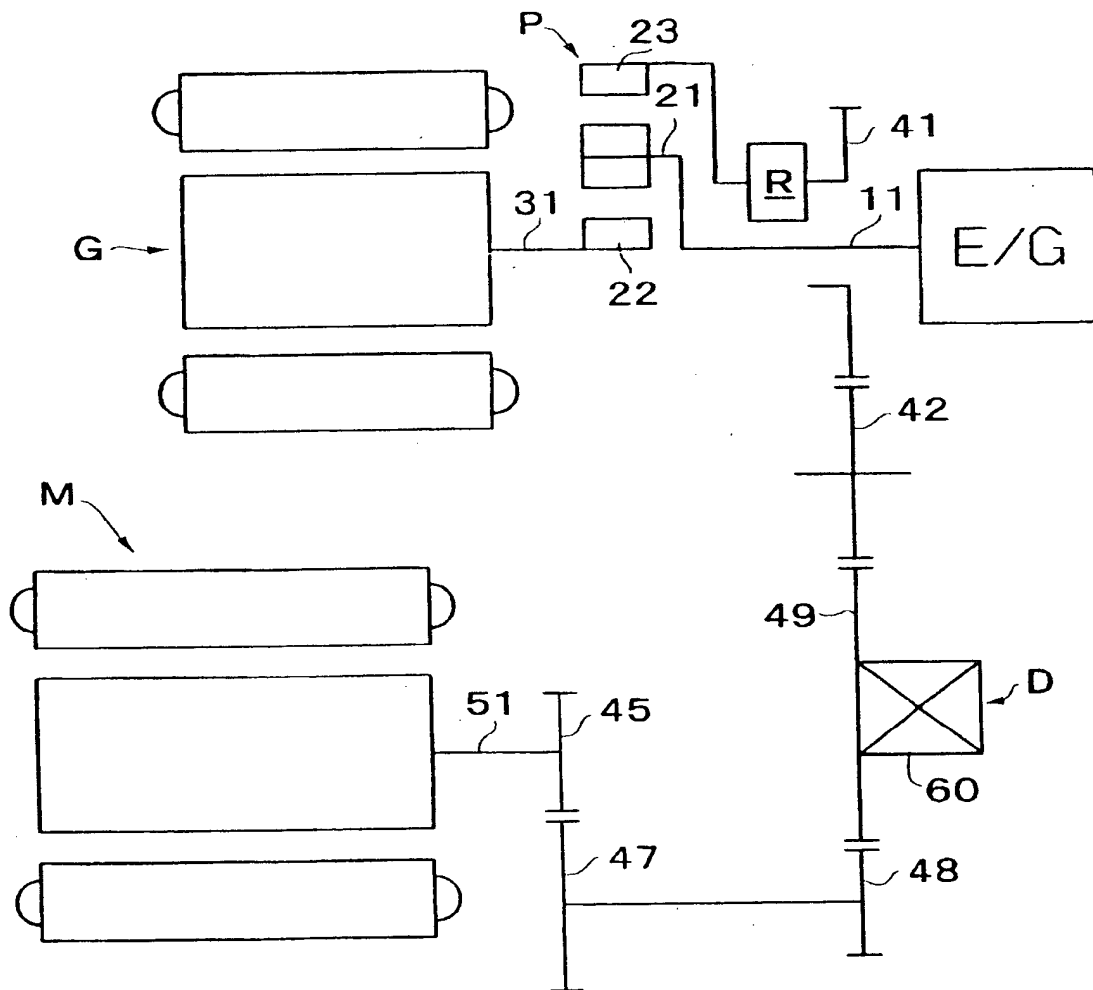


FIG. 11

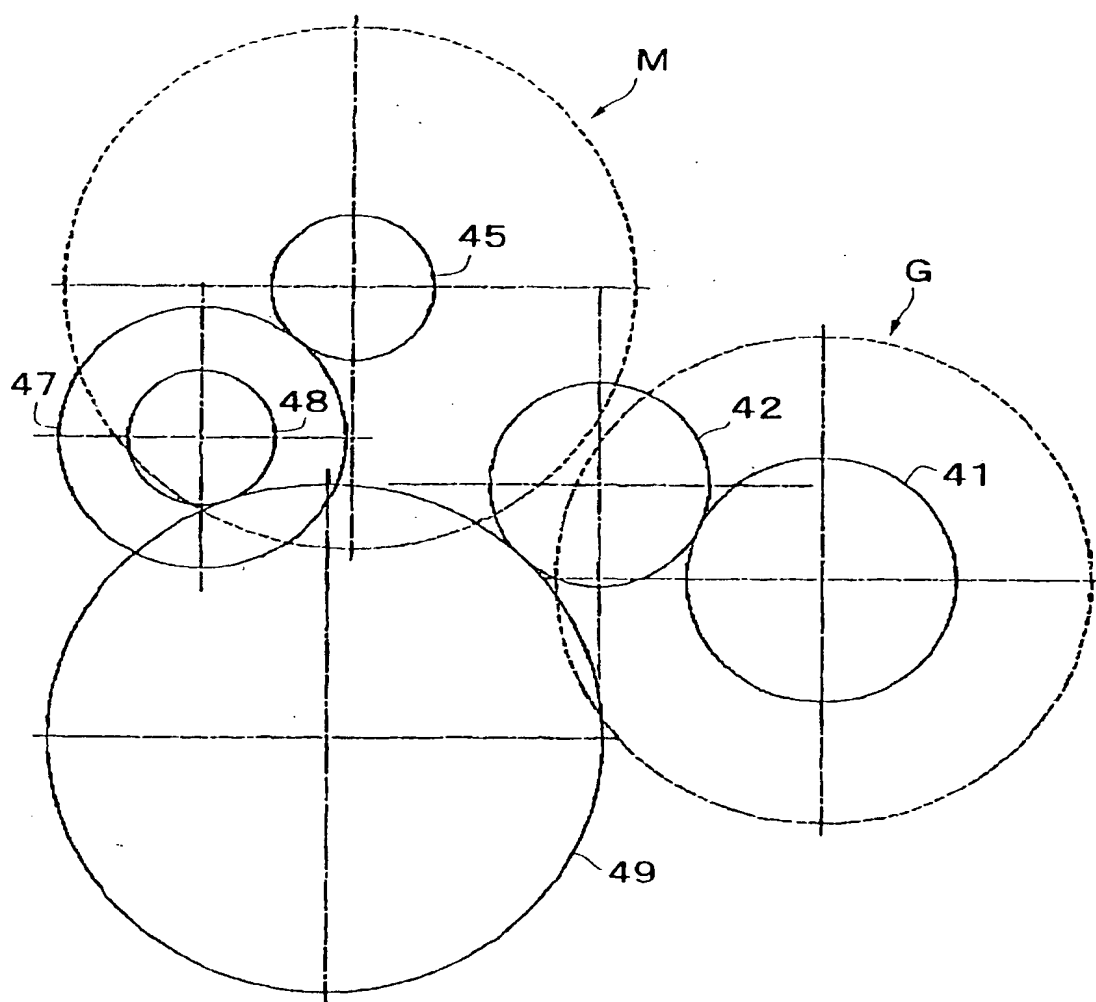


FIG. 12

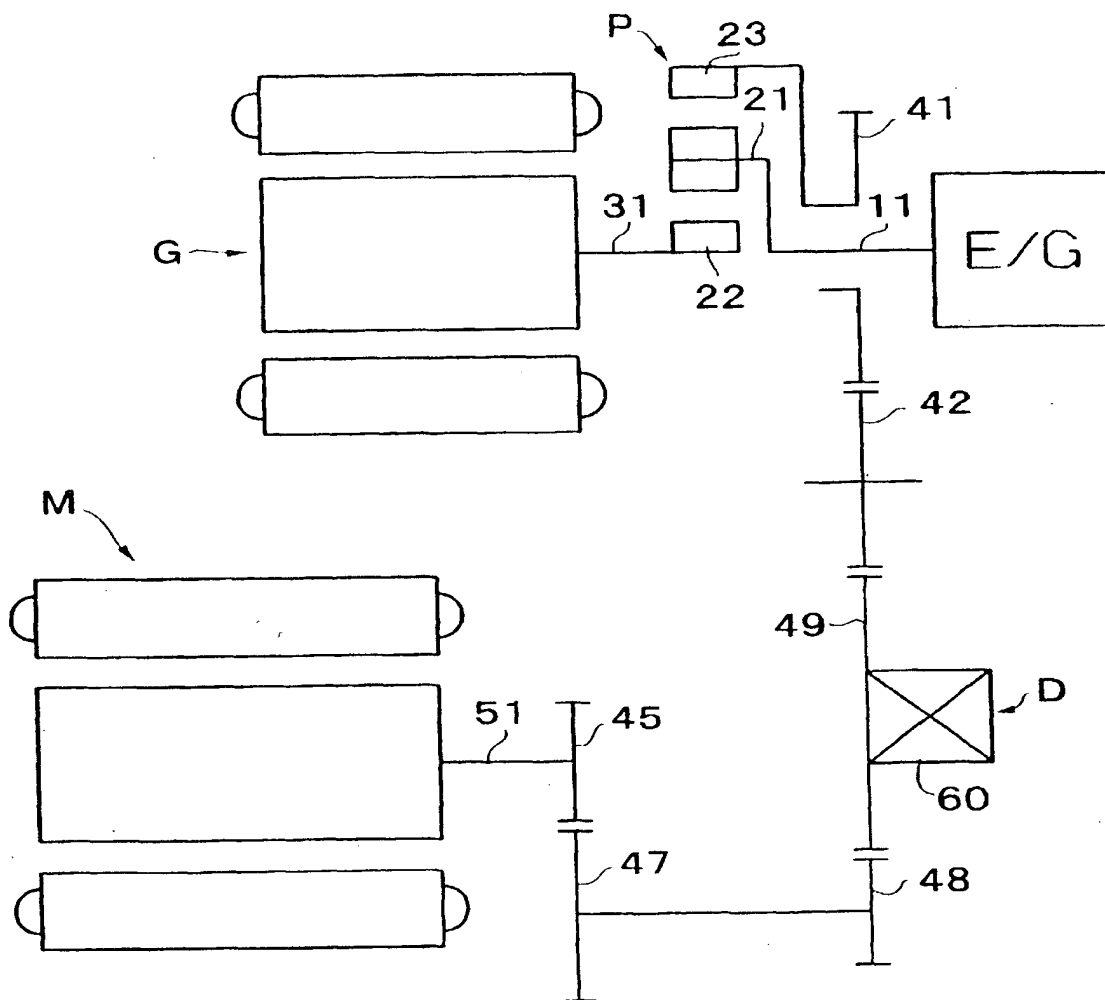


FIG. 13

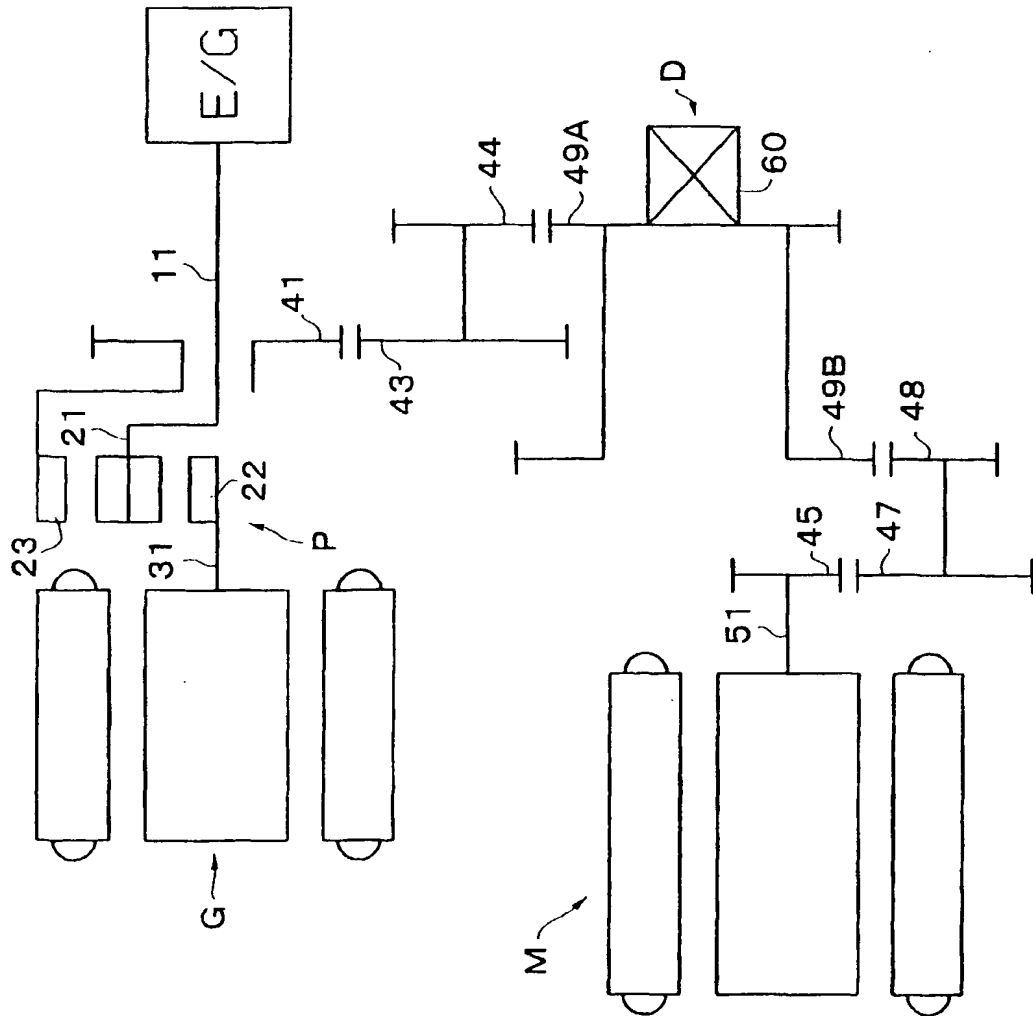


FIG. 14

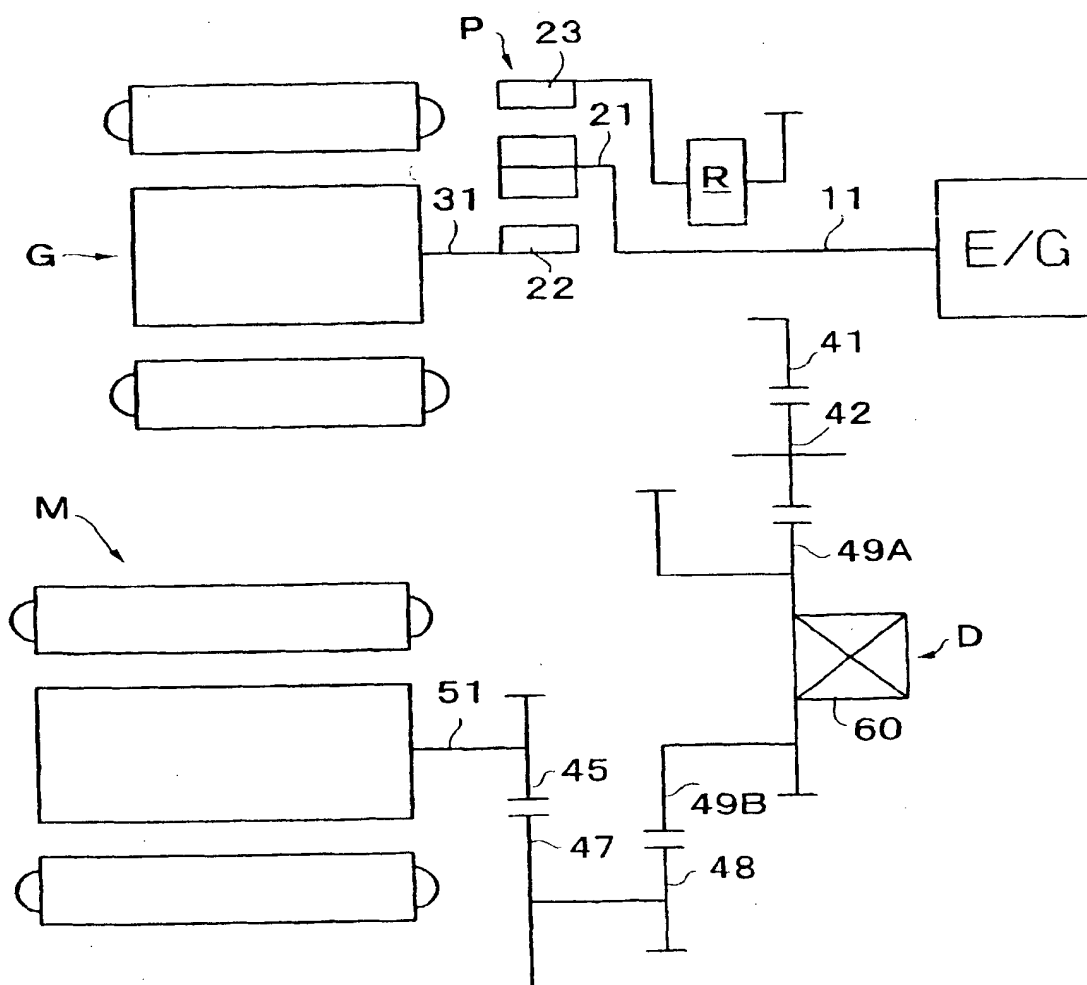


FIG. 15

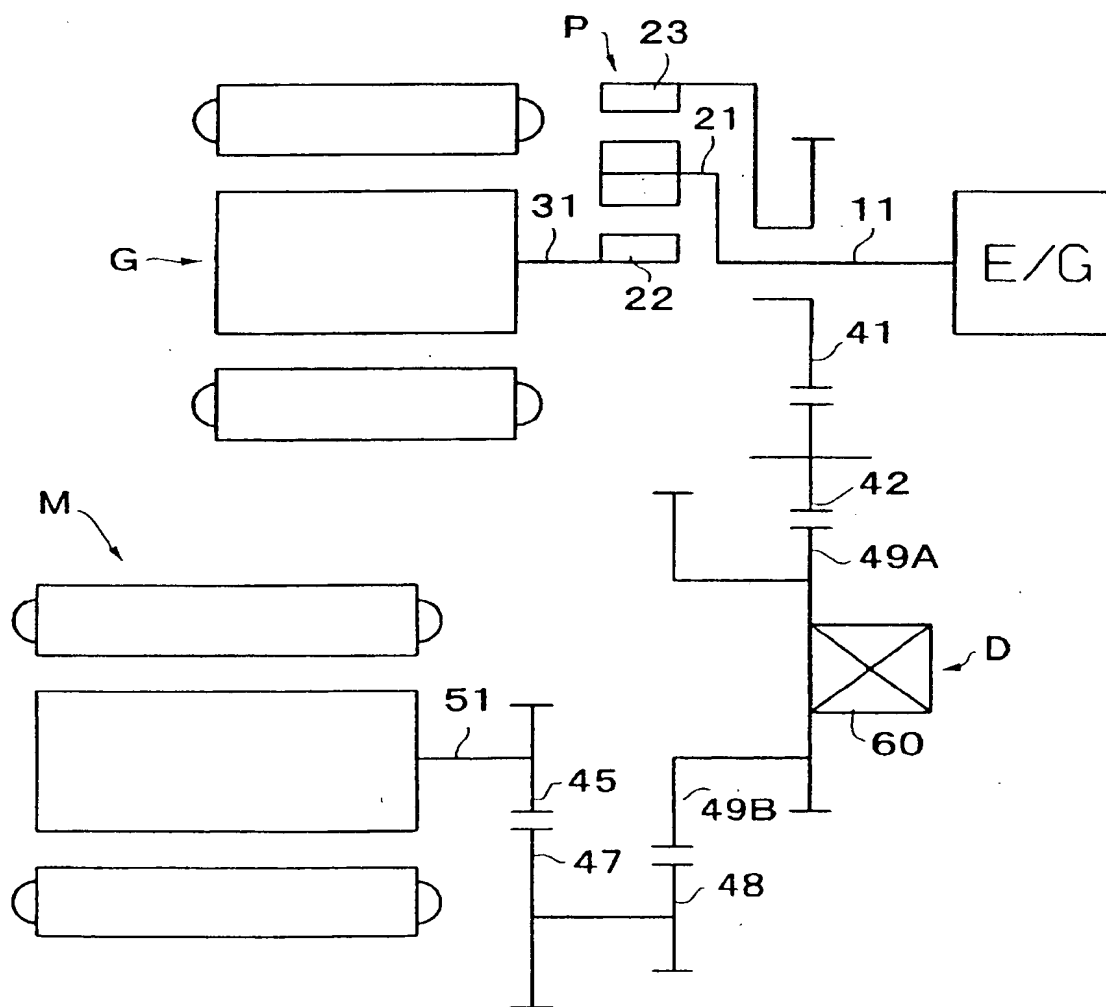


FIG. 16

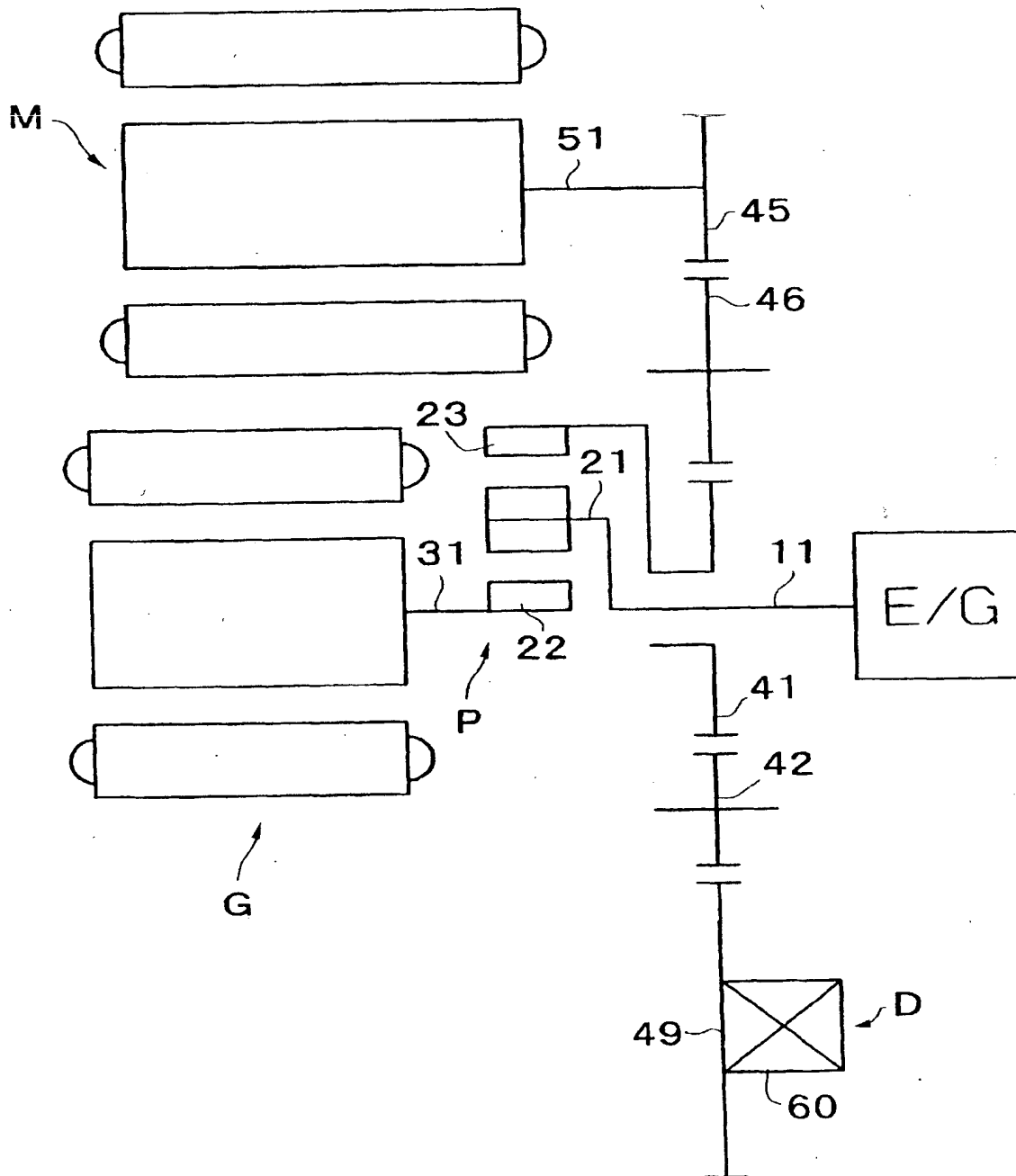


FIG. 17

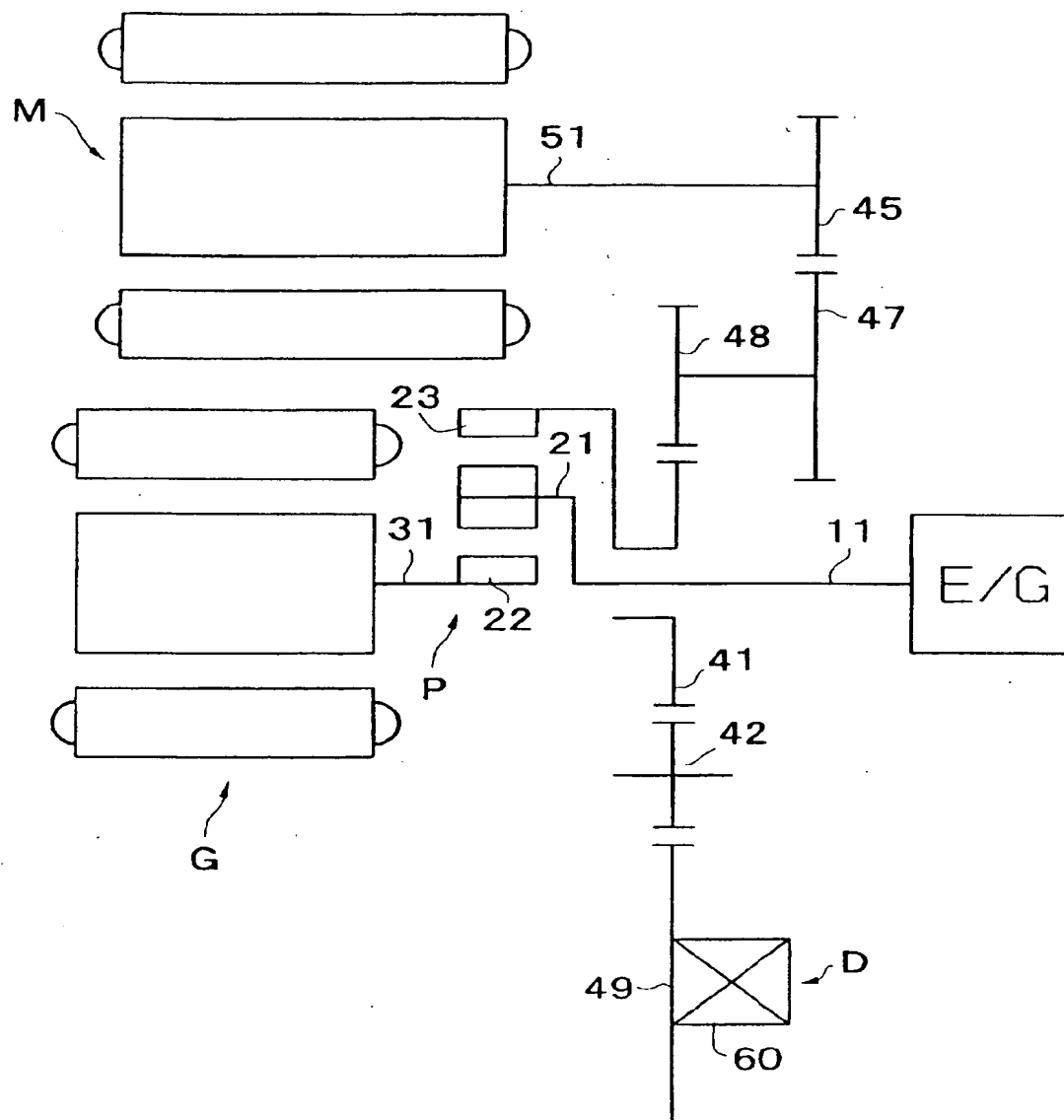


FIG. 18

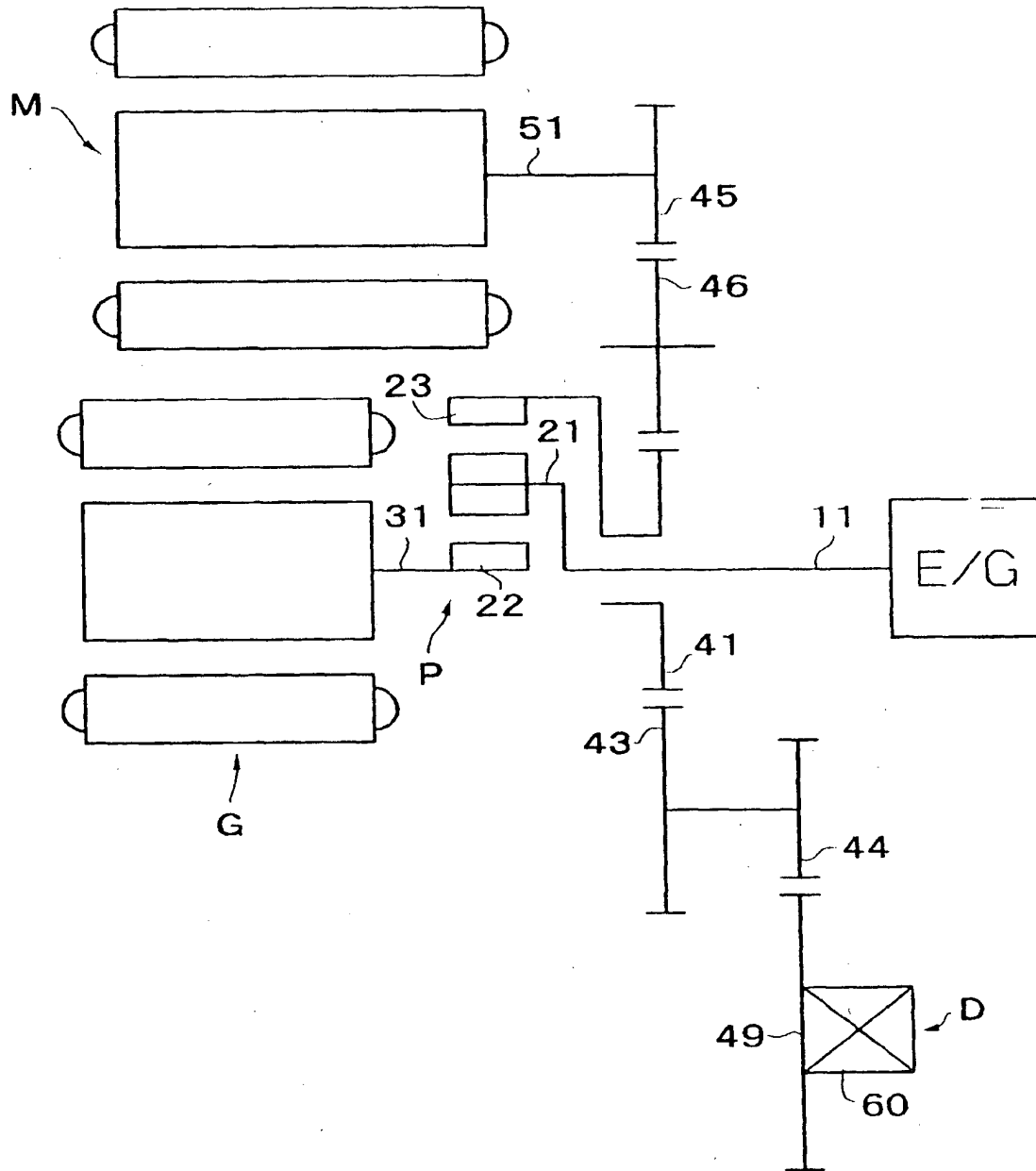


FIG. 19

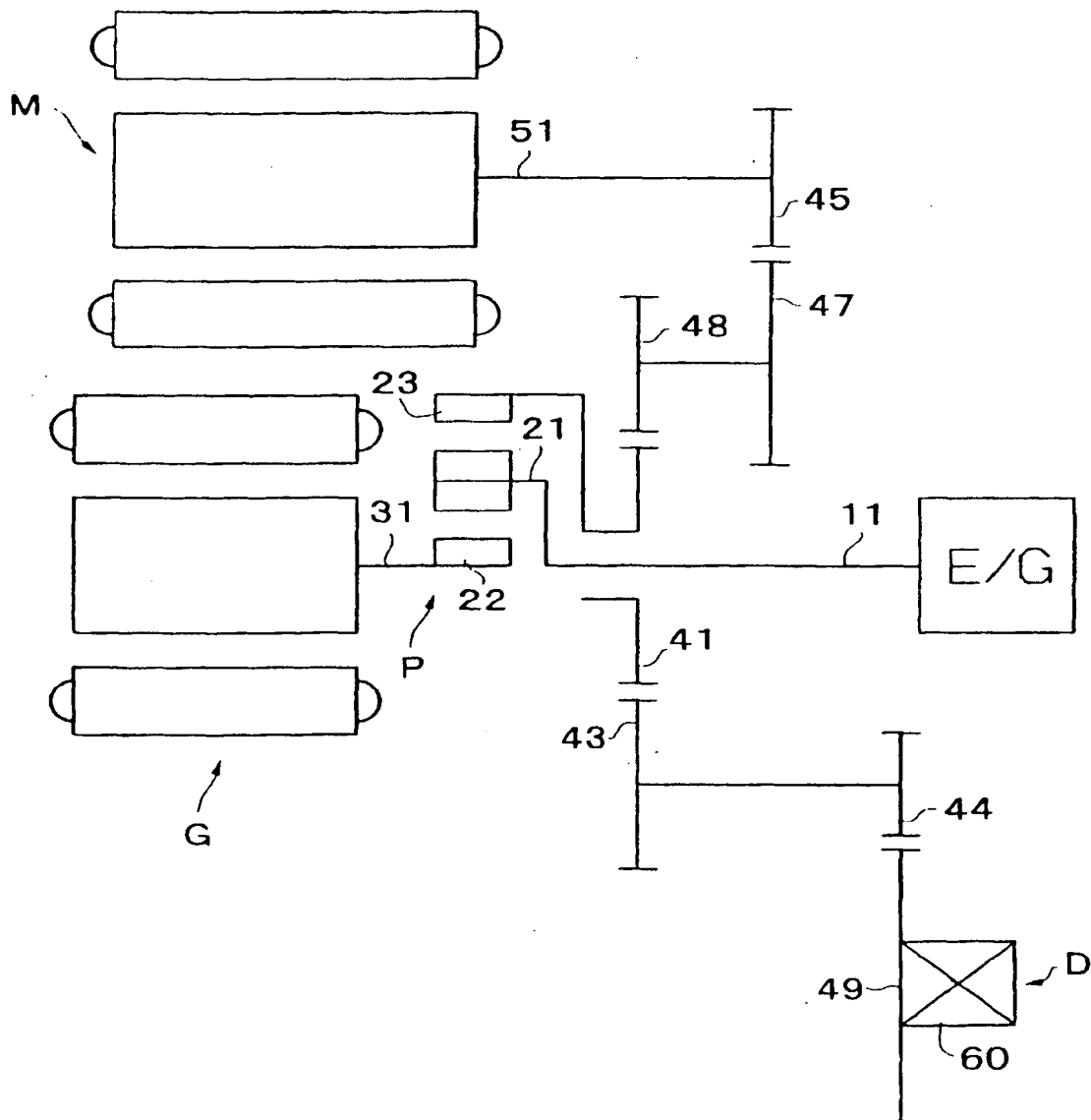


FIG. 20

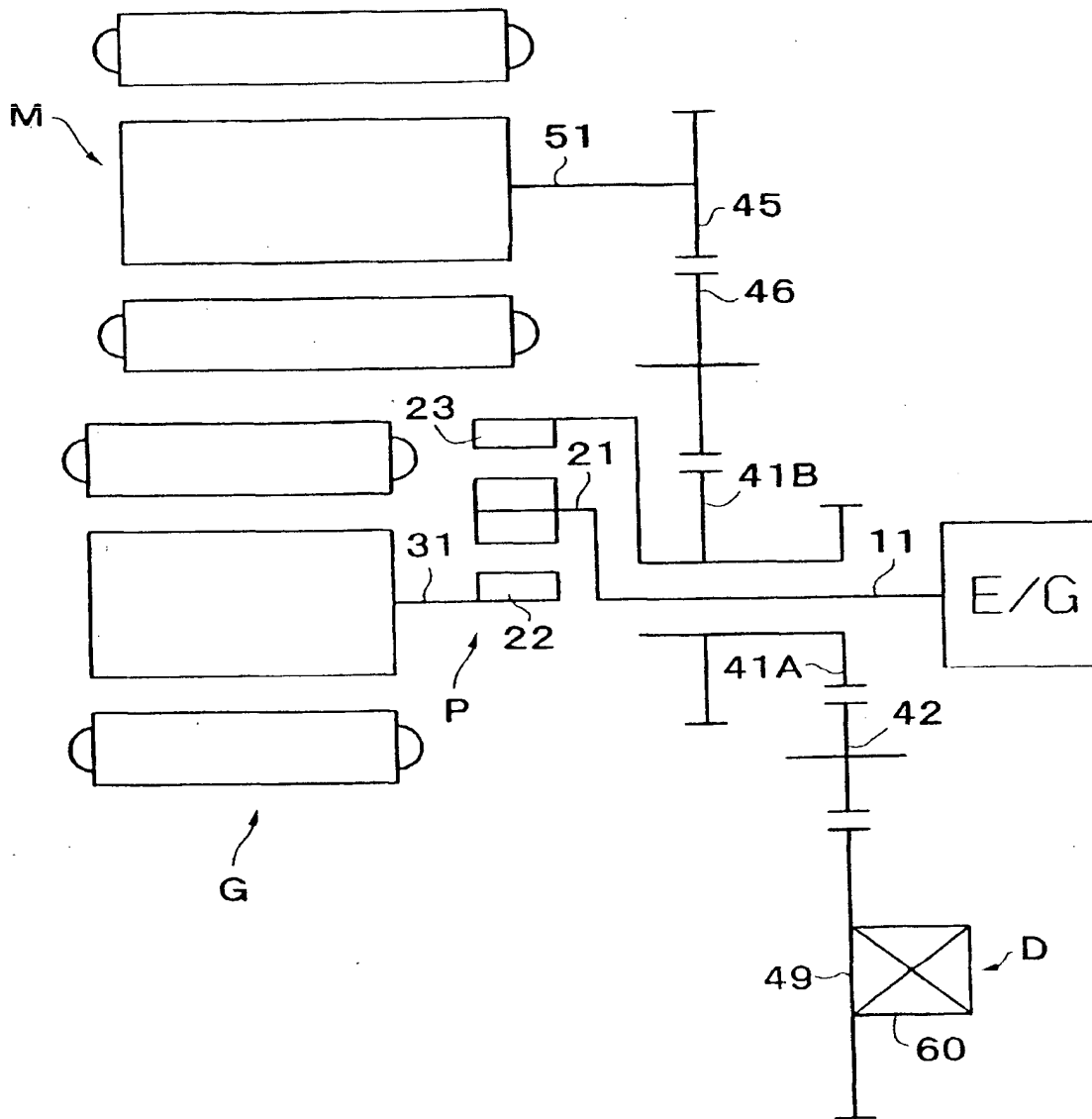


FIG. 21

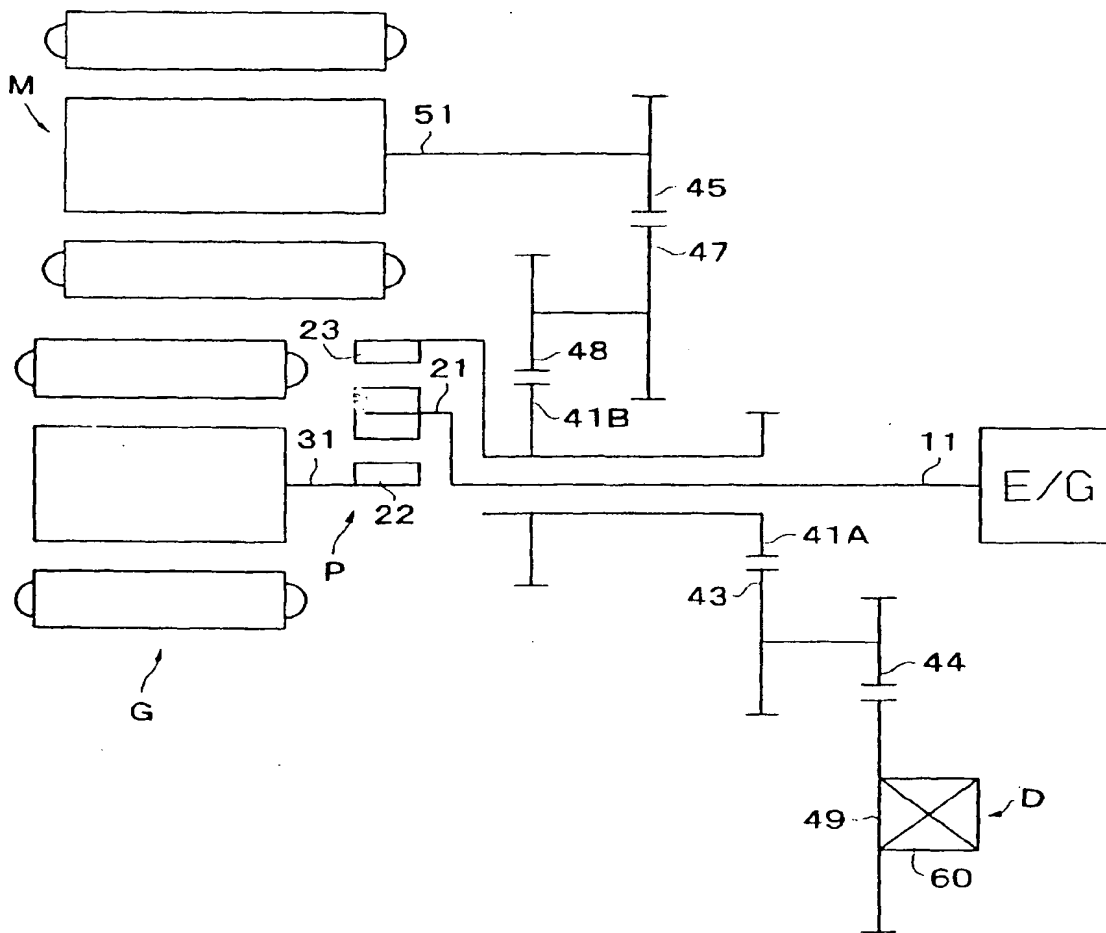


FIG. 22

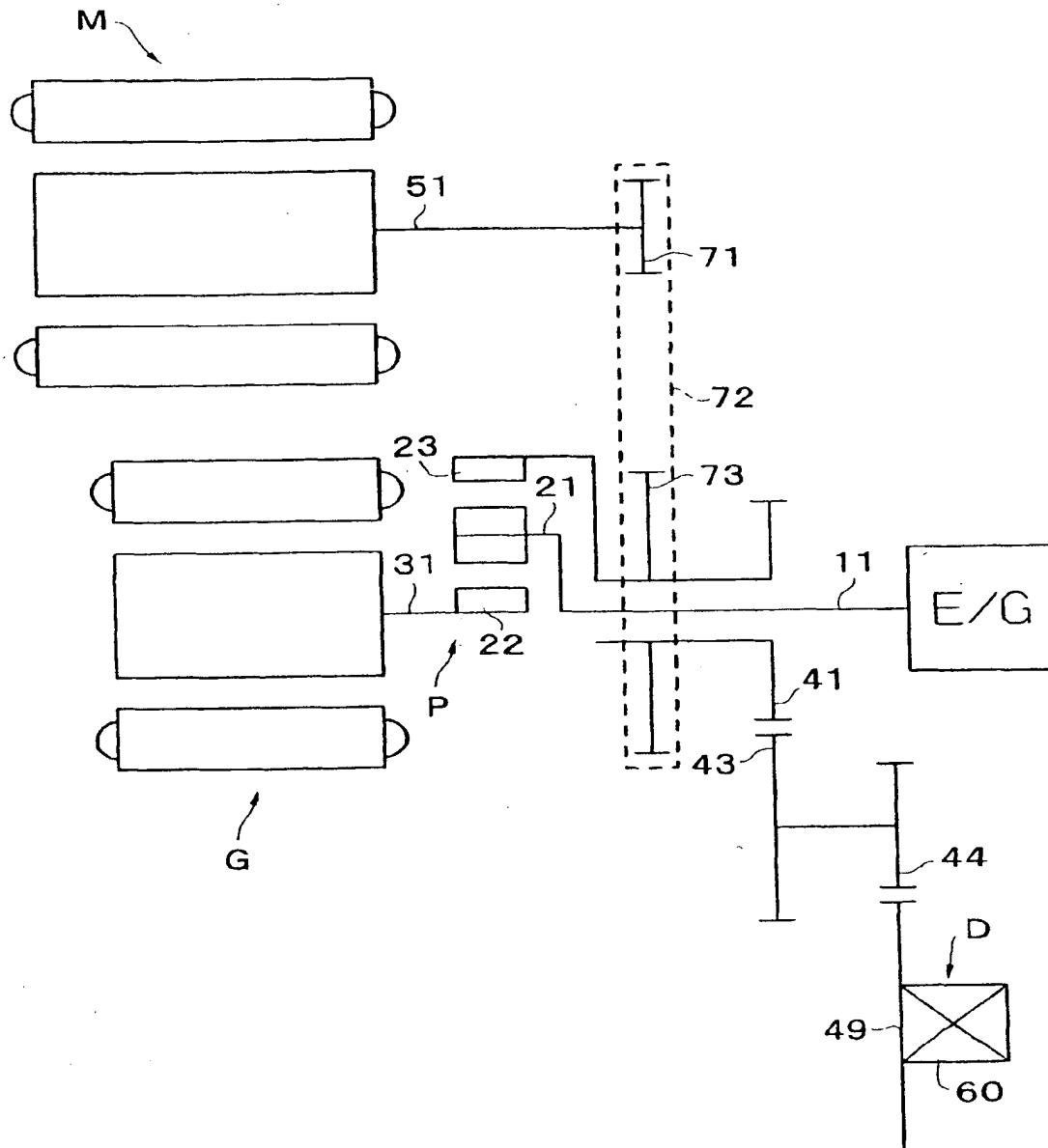


FIG. 23

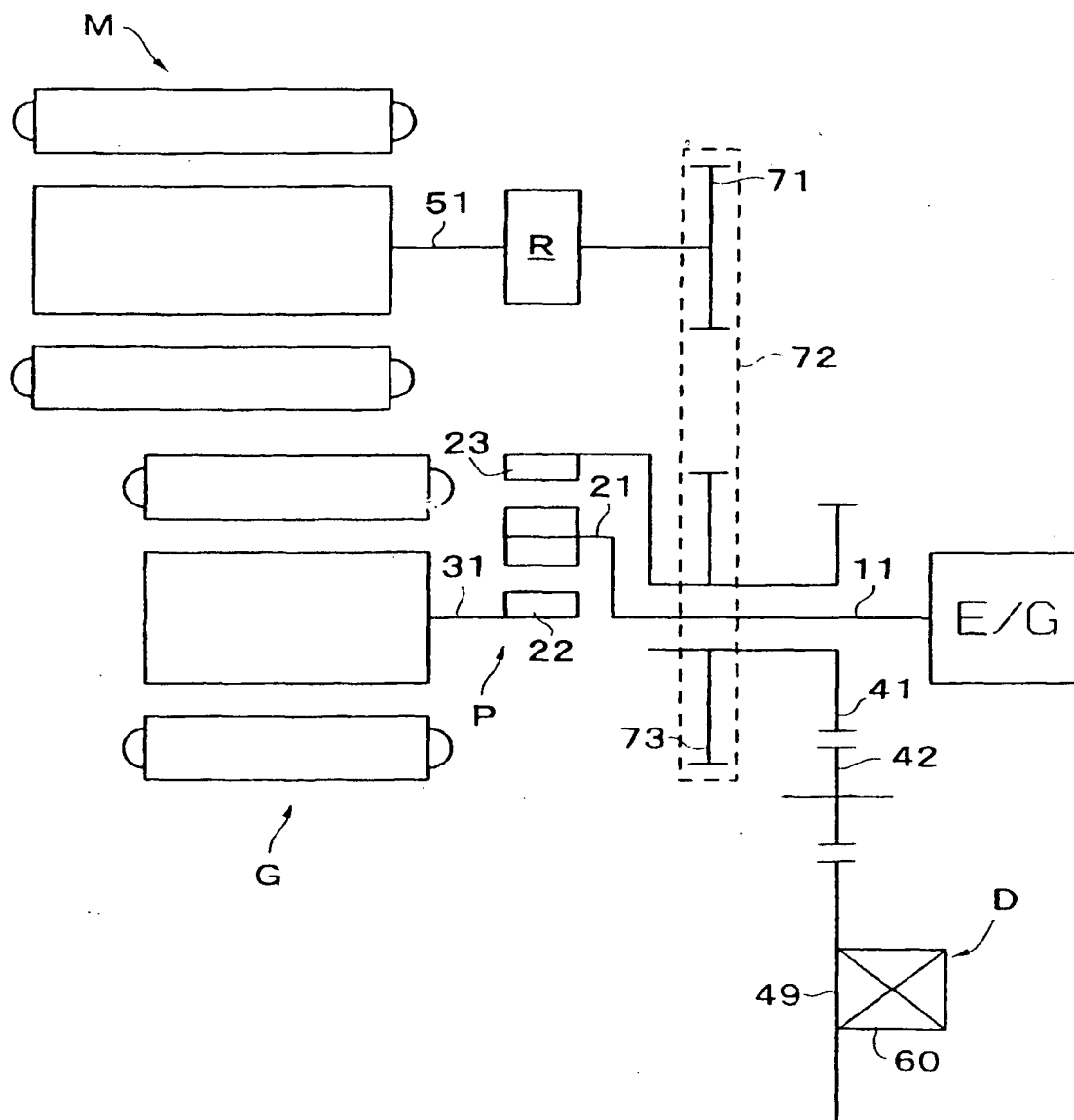


FIG. 24

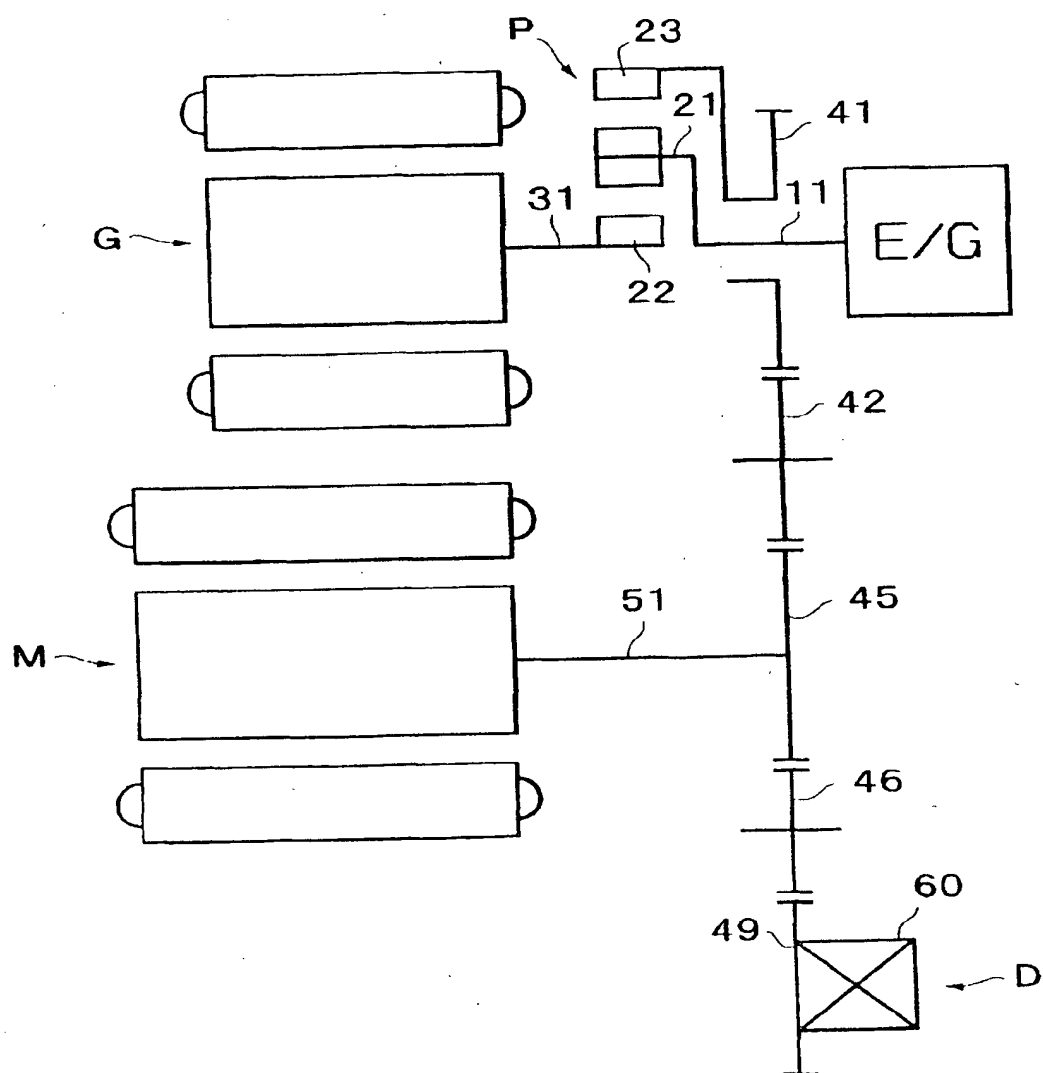


FIG. 25

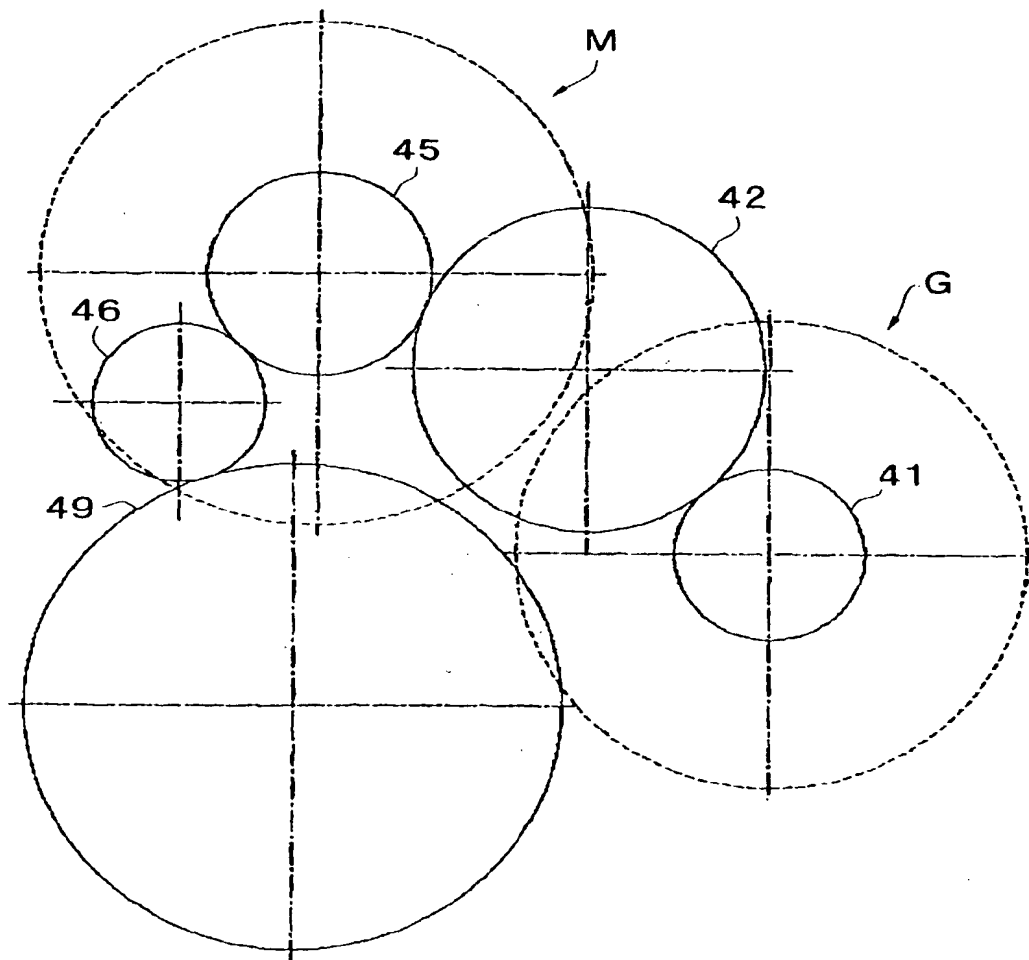


FIG. 26

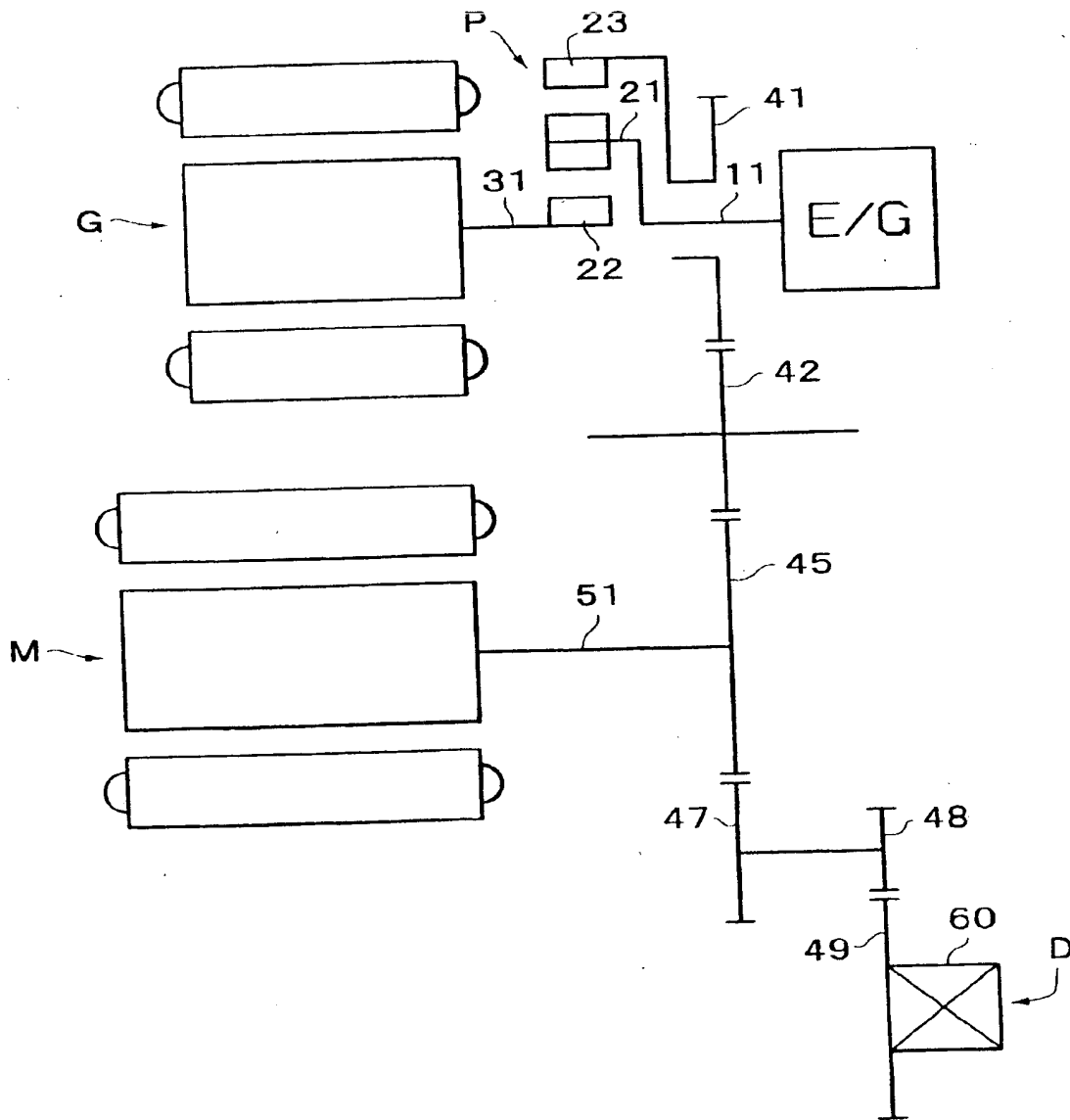


FIG. 27

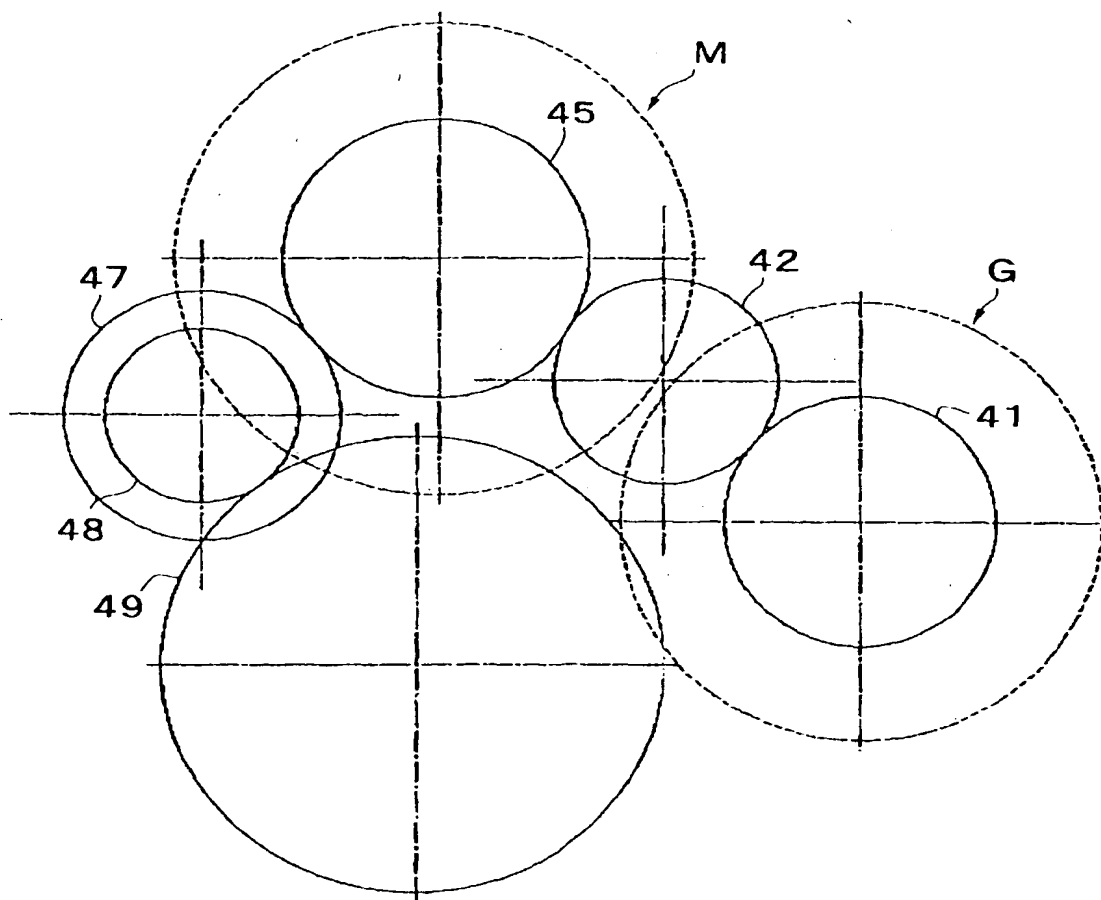


FIG. 28

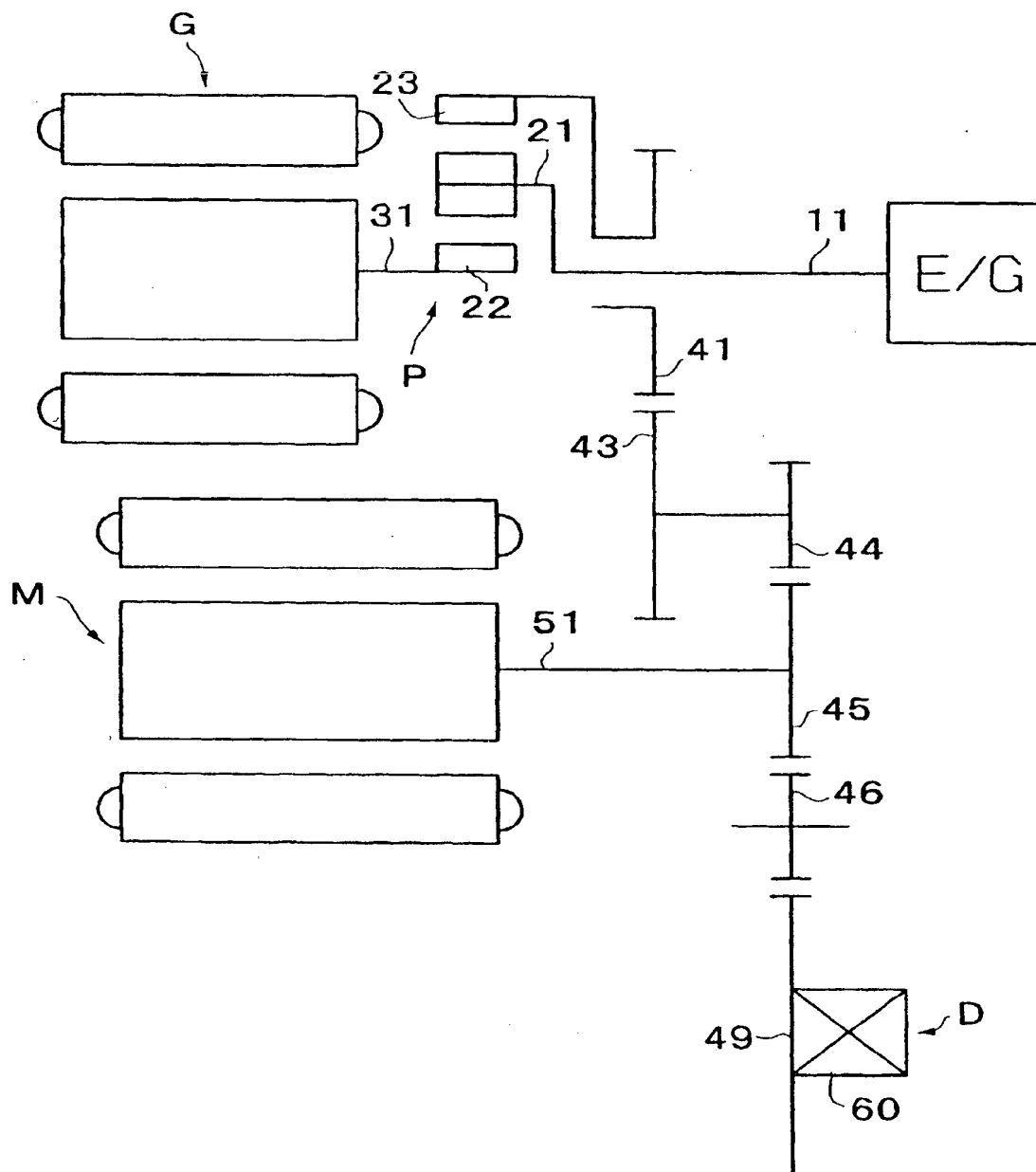


FIG. 29

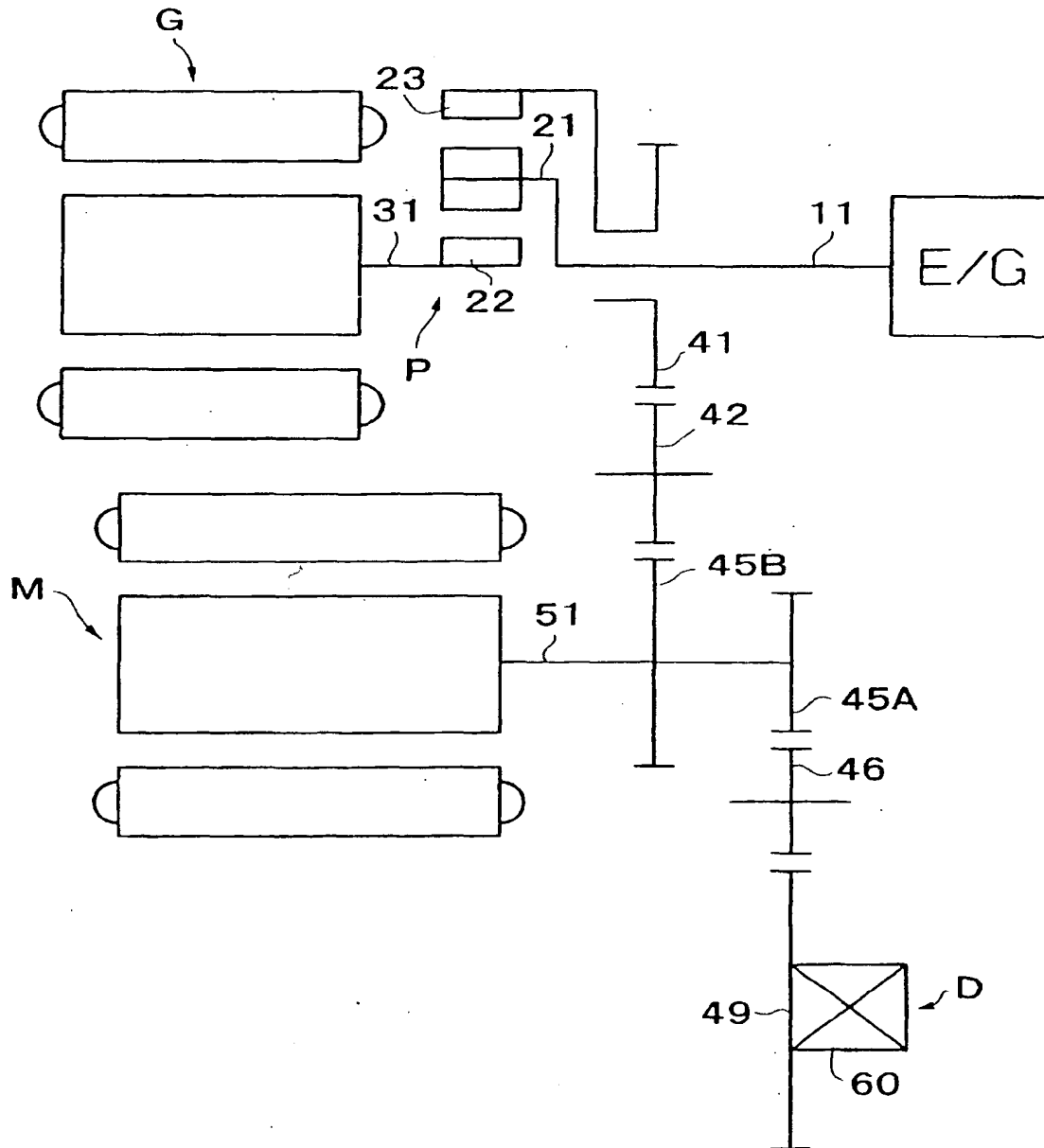


FIG. 30

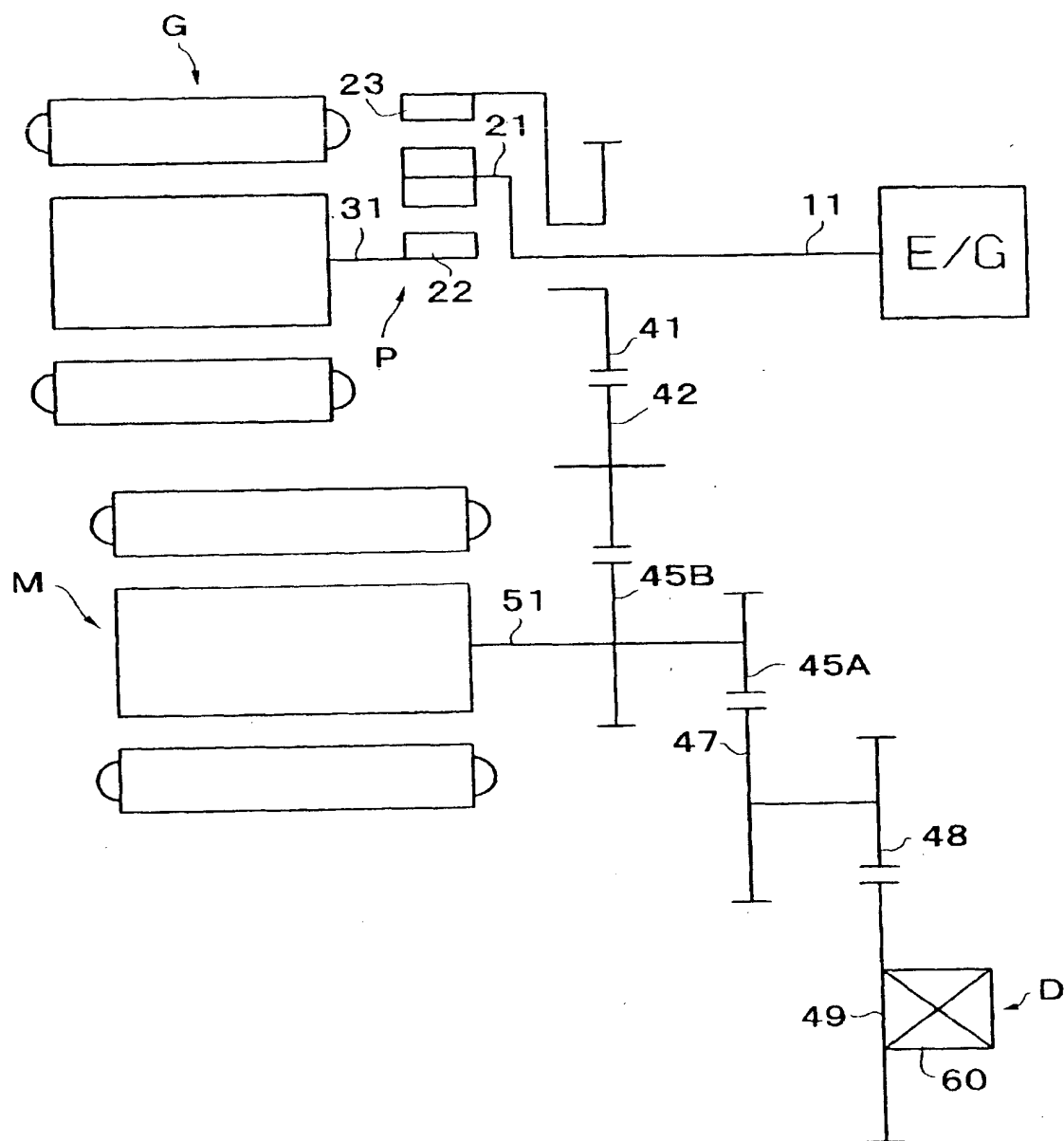


FIG. 31

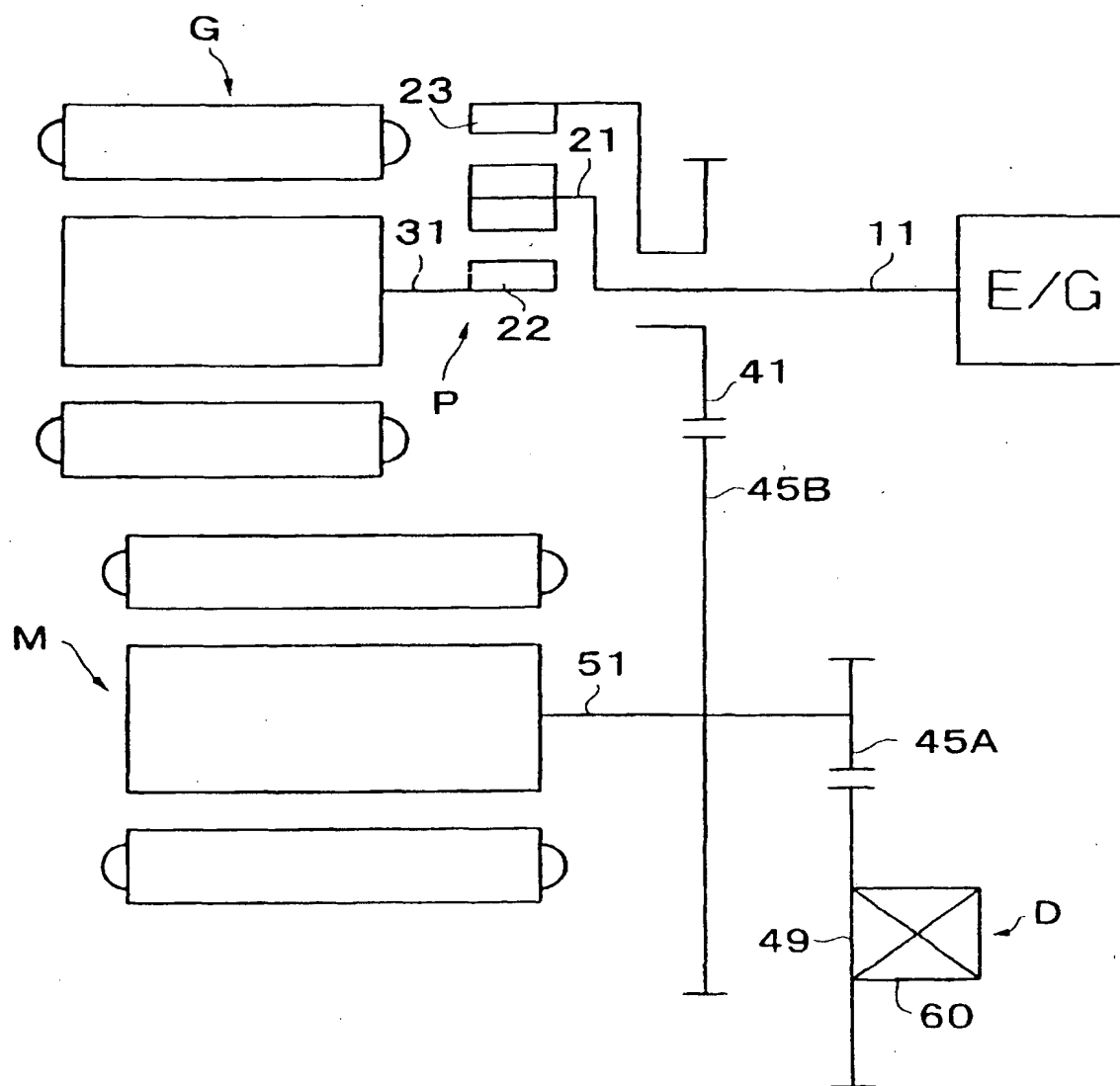


FIG. 32

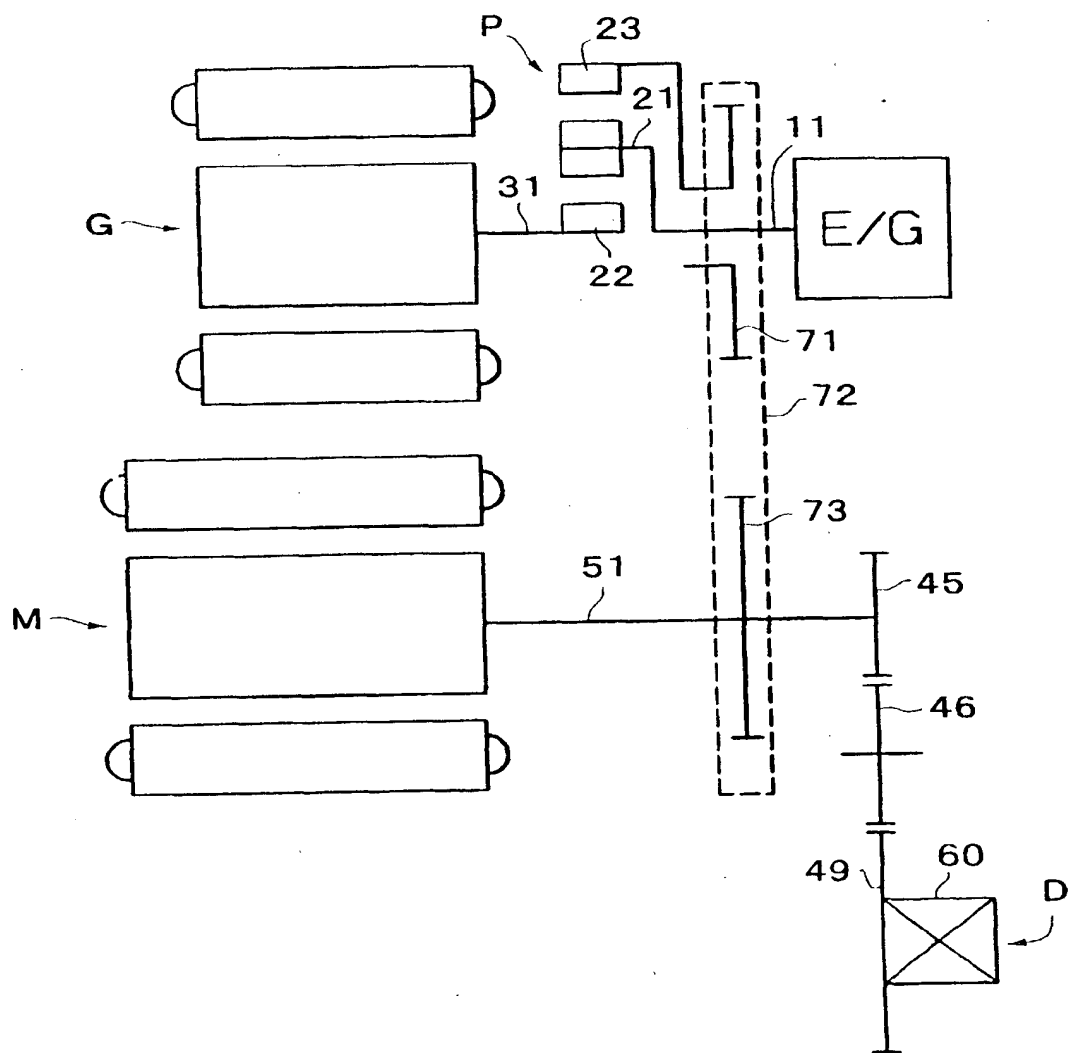


FIG. 33

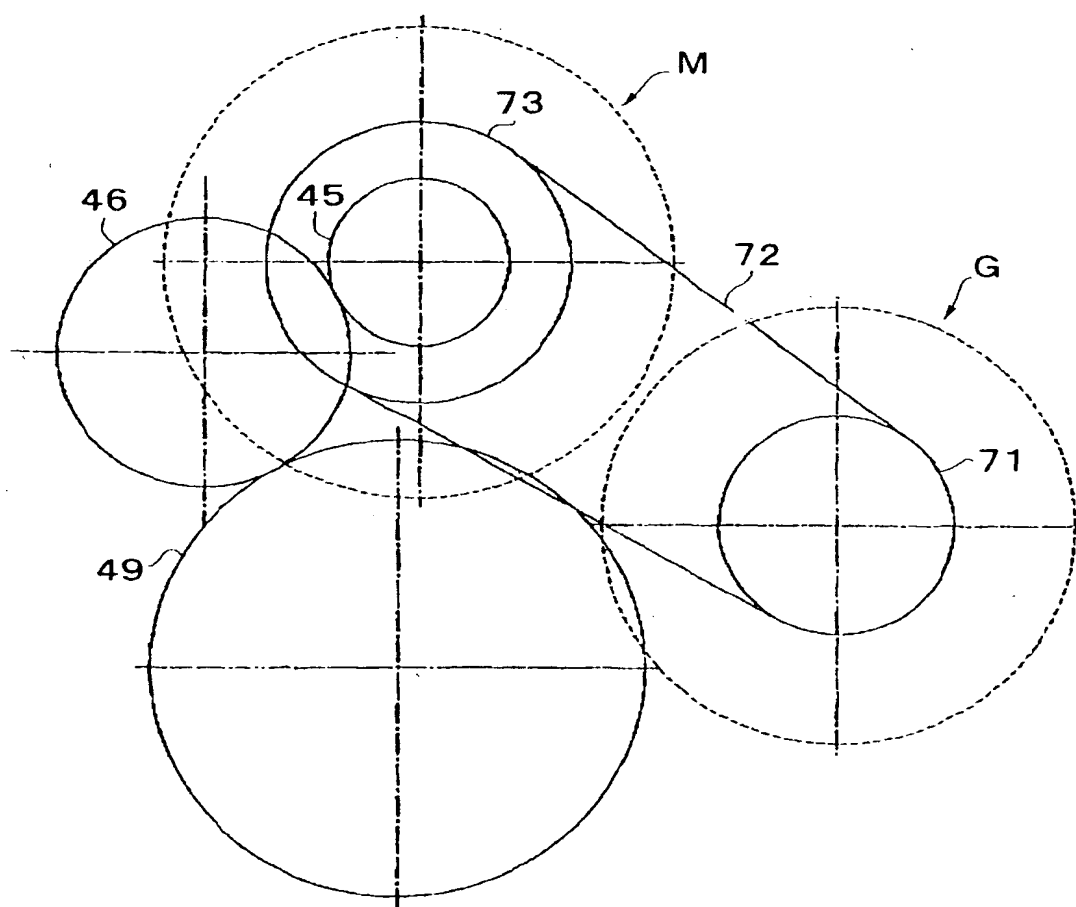


FIG. 34

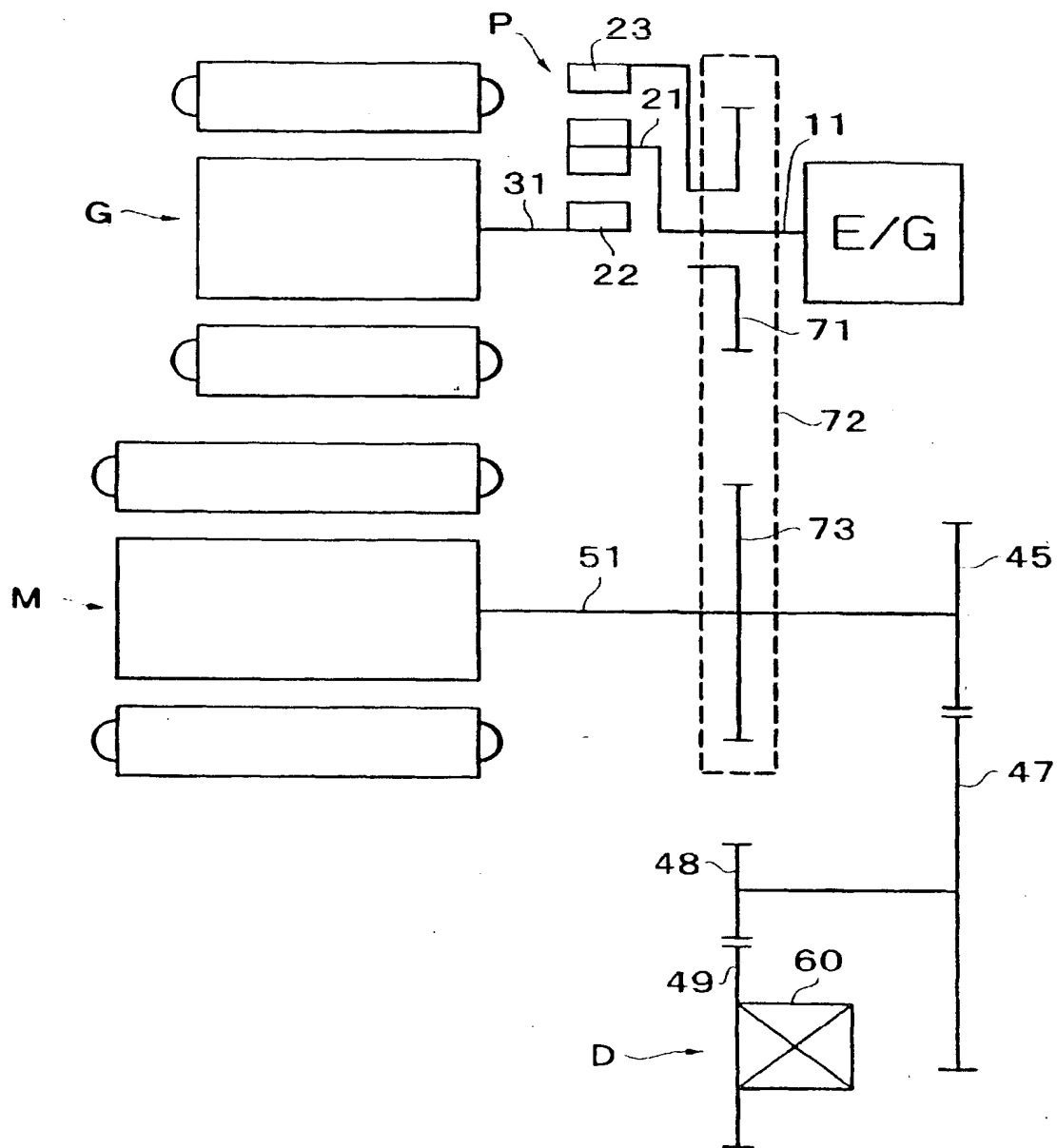
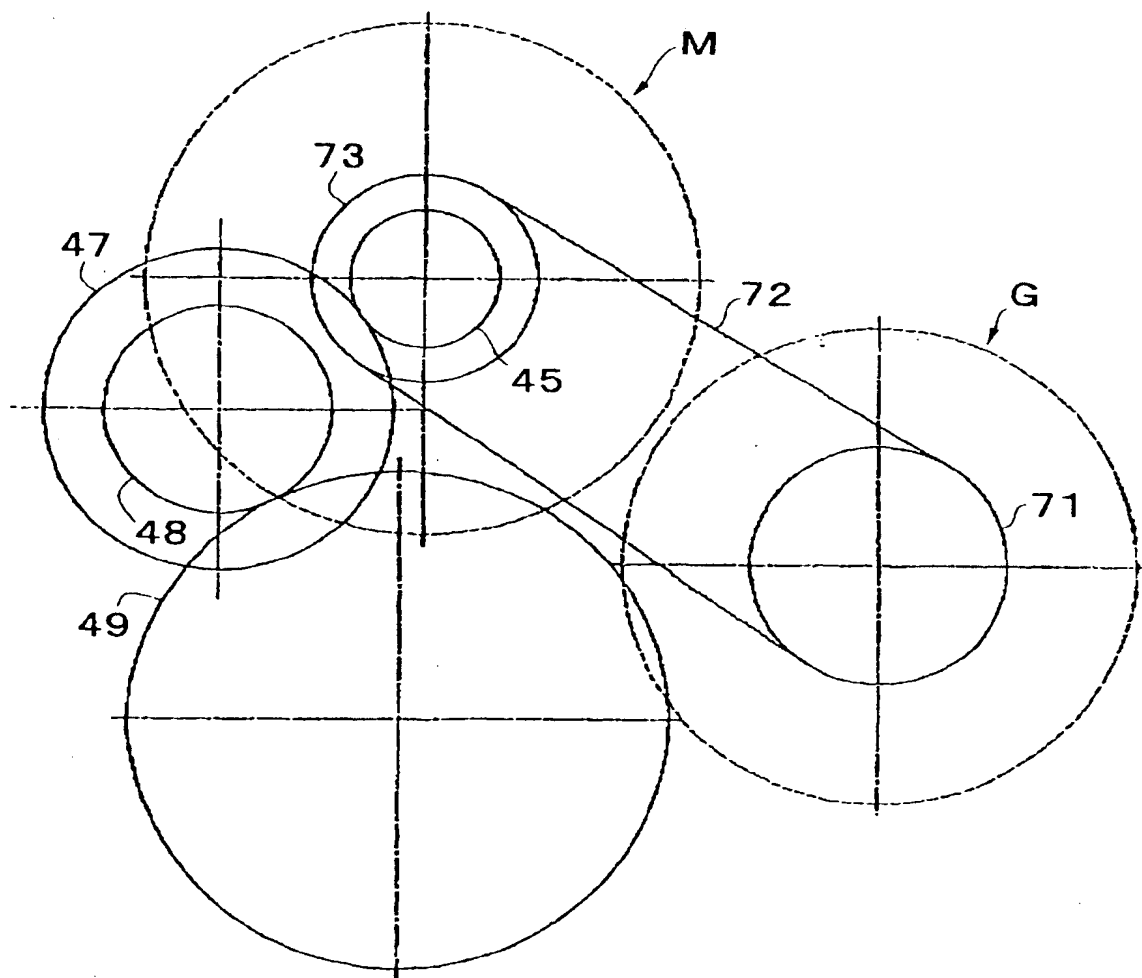


FIG. 35



THIS PAGE BLANK (USPTO)